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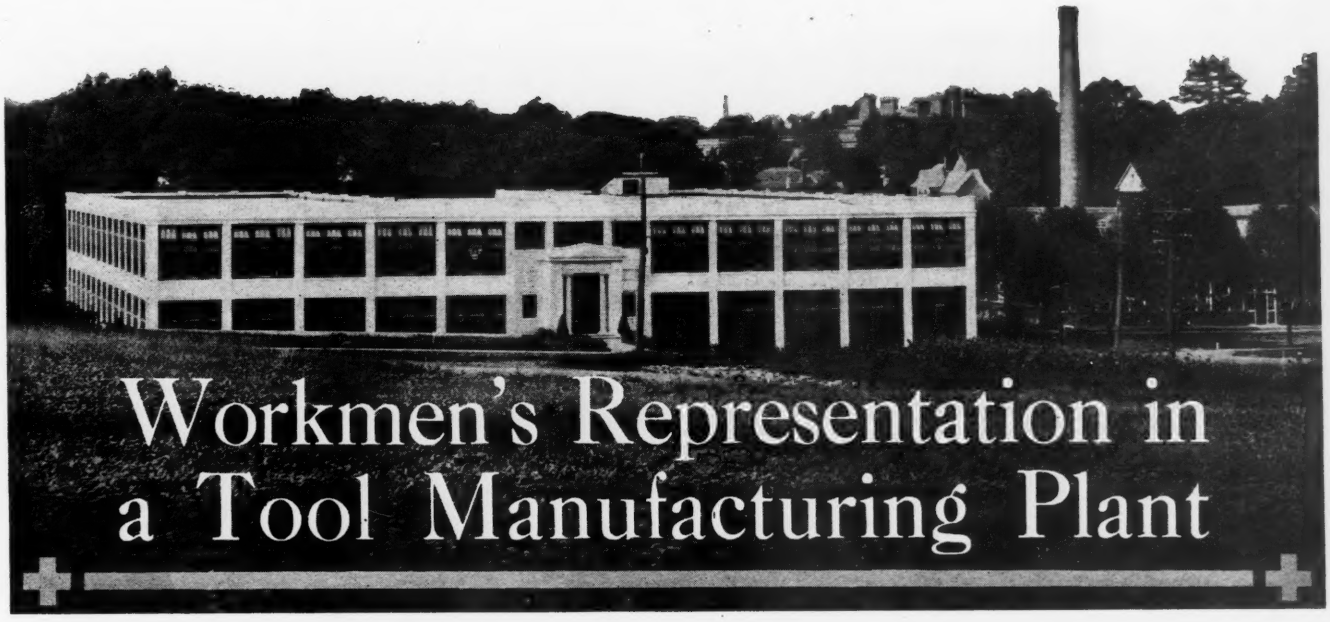


Workmen's Representation in a Tool Manufacturing Plant

An Account of the Methods Used and the Results Obtained by the Greenfield Tap & Die Corporation, Greenfield, Mass., in the Application of Workmen's Representation in the Plants of the Corporation

Based upon interviews with FRANCIS G. ECHOLS, Vice-president and General Manager, L. M. LAMB, Comptroller, and R. P. DOLAN, Head of Industrial Relations Department

THE general industrial conditions throughout the country caused by the war, the unrest among labor, and the many other difficulties that have tended to bring about a reduction in output and a consequent increase in prices, have made it necessary to investigate different plans for promoting greater cooperation between employer and employe with a view to securing greater efficiency. Some of the plans investigated by industrial corporations during the past two or three years were installed in isolated cases years ago, but the conditions created by the war intensified the interest in matters of this kind and made more general the adoption of various plans whereby it is endeavored to obtain a better mutual understanding between the management and the workmen in the industries.

Among the numerous ideas for promoting this cooperation, improving the relationship between employers and employes, increasing the efficiency of labor in production, and providing an equitable means for increasing the compensation of the workers, the plan which has received the greatest attention is the method which gives to employes a voice in the management of the plant in so far as this is concerned with the working conditions and the general welfare of the men and women in the industries. The opinions of the workers are expressed through representatives elected by them, and the movement as a whole is known by such names as the Shop Committee Plan, Workers' Council Plan, Employes' Representation, Workmen's Representation, and Industrial Democracy.

It is believed that the term "workmen's representation" best describes this idea of industrial management, because it is descriptive of the general plan. The workmen's representation plan has been defined as a form of industrial organization under which the employes of the factory, through representatives chosen by and from among themselves, share collectively in the adjustment of employment conditions in the plant. It serves as a means of satisfying the employe's natural desire for a share in the determination of the conditions under which he works. The plan further endeavors to increase production by the cooperation fostered between the management and the workmen, and to stimulate the interest of the workmen in the welfare of the company by sharing with them, in the form of an additional wage payment or dividend, that part of the profits due to this cooperation.

One of the first plants in the country among the tool manufacturers to apply this new principle of management is the Greenfield Tap & Die Corporation, which operates six plants in Greenfield, Mass., and employs about 2000 people. The purpose of this article is to state in detail the methods by which the principle of workmen's representation has been applied in the various plants of this corporation and to show the results during one year's application of the principle.

During the past year a great deal of attention has been given by manufacturers to the experiment of workmen's representation, which is being tried out in some of the industries. Few manufacturers of machine tools and small tools have taken active steps along this line, and the Greenfield Tap & Die Corporation, Greenfield, Mass., is one of the first, if not the first, in this field to inaugurate a complete plan for workmen's representation. As manufacturers are interested in any plan of management intended to improve industrial conditions and stimulate production, this first complete review of the workmen's representation idea, as applied in the machine tool field, is published in MACHINERY as a record of this plan, showing what the experience in one large organization has taught concerning it.

The Object of the Greenfield Tap & Die Corporation's Plan

The two fundamental principles upon which the plan adopted by the Greenfield Tap & Die Corporation is based relate, first, to the duties of the management and, second, to the duties of the employes. The management endeavors to give just returns for work performed and to provide an opportunity for the employes to learn and progress. It endeavors to establish clean, orderly, safe, and sanitary working conditions, satisfactory equipment and reasonable hours, with opportunities for recreation and rest. The workers, in turn, are expected to give honestly applied labor, constructive thought with a view to reduction of costs, and to endeavor to cooperate with the management in preserving and improving the quality of the product. The workmen further cooperate with the management by regular attendance and punctuality, and by discouraging indifference, restriction of output, or poor workmanship on the part of any of their fellow-workers. It is believed that if both the management and the workers observe these principles, a better mutual understanding will be effected, and the management and the employes alike will benefit by the cooperation.

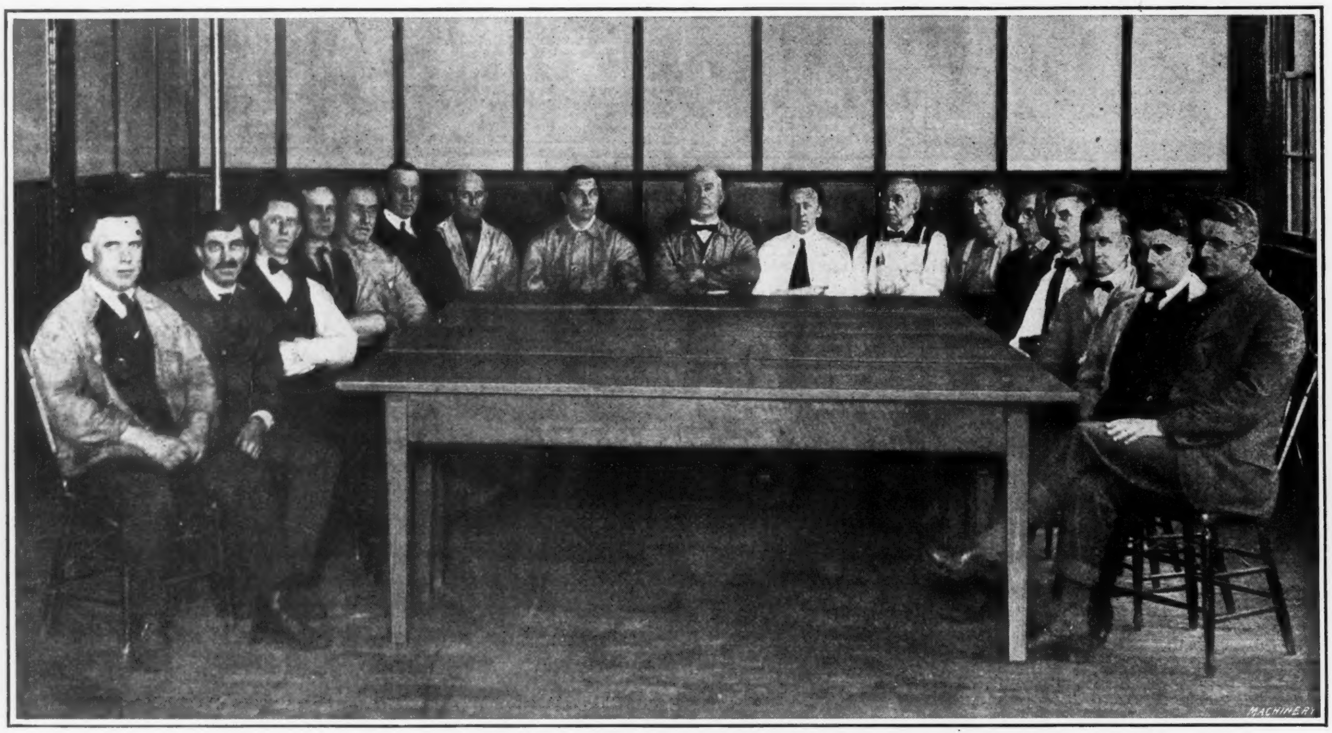


Fig. 1. The Judiciary in Session at One of the Plants of the Greenfield Tap & Die Corporation. The Judiciary is composed of the Foremen of the Plant

The method by which the aims outlined are obtained is by creating an association among the employes through which questions relating to working conditions and living conditions affecting the welfare of the employes may be brought to the attention of the management, and be thoroughly discussed so that decisions may be reached by mutual agreement. The association of employes, through its representatives, also possesses a means for the equitable adjustment of any difference that may arise between individual employes and their foremen, or between the employes in general and the management. This reduces the cost and waste due to misunderstandings, and the saving obtained by the reduction of this waste is shared equally by the employe and the employer.

General Outline of the Representation Plan

The association of employes just referred to is known as the G T D Associates. Employes of any department in any capacity who have been in the employ of the corporation for a continuous period of one month are eligible to membership. The general routine of the association is handled by the industrial relations manager, who acts as a general secretary of all the activities involved in the workmen's representation plan. When an employe wishes to become a member of the association, he applies to the industrial relations manager for membership. Upon verification of his employment record, the applicant is entered as a member. Membership in the association entitles the employe to full consideration of any question that he may wish to bring up through the chosen representatives and entitles him to a vote at the annual meeting, which is held in May, for the election of representatives for the coming year, as well as a vote at any special meetings of the membership that may be called to fill vacancies among the representatives. When a member leaves the employ of the corporation, he automatically ceases to be a member of the association.

The general plan of management in as far as it relates to the employes' representation comprises a legislature, which is composed of representatives of all the skilled and unskilled workers in the plant, there being one representative for each twenty employes, or fraction thereof, in each department. If a department has less than twenty employes, it elects one representative. There is a second body known as the judiciary, which is composed of the foremen, assistant foremen, and department heads, and there is a third body known as the executive council, which is composed of the factory manager, the superintendents, and the general foremen. Finally, the whole organization is headed by the chief executive—in this case the general manager of the corporation's plants.

The Duties and Powers of the Legislature

As the corporation operates several different plants, there is a separate body of workmen's representatives in each of the three larger plants, while some of the smaller plants are grouped together for representation in one unit. For the purpose of this article, it will be sufficient to take as an example the organization and working of the representation in one of the plants only. Referring especially to the Wells Bros. Division of the corporation, it may be mentioned that the 350 employes of this division have 26 representatives, who meet once a month to discuss the questions or "bills" brought up by the different members.

The representatives to the legislature are elected for one year, and to be eligible for election, a representative must have been in the service of the corporation continually for at least one year immediately preceding election. The object

of this restriction is to prevent any worker from having a voice as a representative who has not been in the employ of the corporation for a period sufficiently long to make him thoroughly conversant with the conditions in the plant. Should this restriction, however, deprive any department of sufficient representatives, members of that department who have been in the continuous employ of the corporation for over six months immediately preceding election may be added to the list of eligible representatives. Both the nominations and the elections are conducted by secret ballot, and twice as many members are nominated by each department as the number allowed for representation. It is not necessary here to give all the details of the election system, but it should be mentioned that the methods and the supervision of the elections are worked out in great detail in order to prevent any possible chance of dissatisfaction with the results, or any coercive or fraudulent practices, and carefully drawn provisions are made for the guarding and recounting of the ballots in cases of disputes or doubts.

The newly elected legislature at its first meeting elects a president, a vice-president, and a recording secretary from its own numbers. The industrial relations manager announces the date, place, and time of the monthly meetings to be held. These meetings take place on the company's time, and representatives working on piece-work receive compensation in the form of an adjustment made to correspond to their lost earnings. The meetings seldom require more than one hour.

Special meetings of the legislature may be called upon the request of two-thirds of its members, who make a written appeal to that effect to the industrial relations manager at least one week in advance of the date of meeting. Attendance at the meetings of the legislature is restricted to members, but courtesy of attendance is extended to members of the judiciary and the executive council, and to the chief executive, who have the privilege of entering into the discussion but have no power to vote. The industrial relations manager is a member ex officio of every committee, attends all meetings, has the privilege of entering into the discussions, but no voting power. He is the connecting link between the management and the "Associates." When the legislature has passed upon the proposals made, it either refers them to the judiciary for action or to either one of the standing committees of which more will be told later.

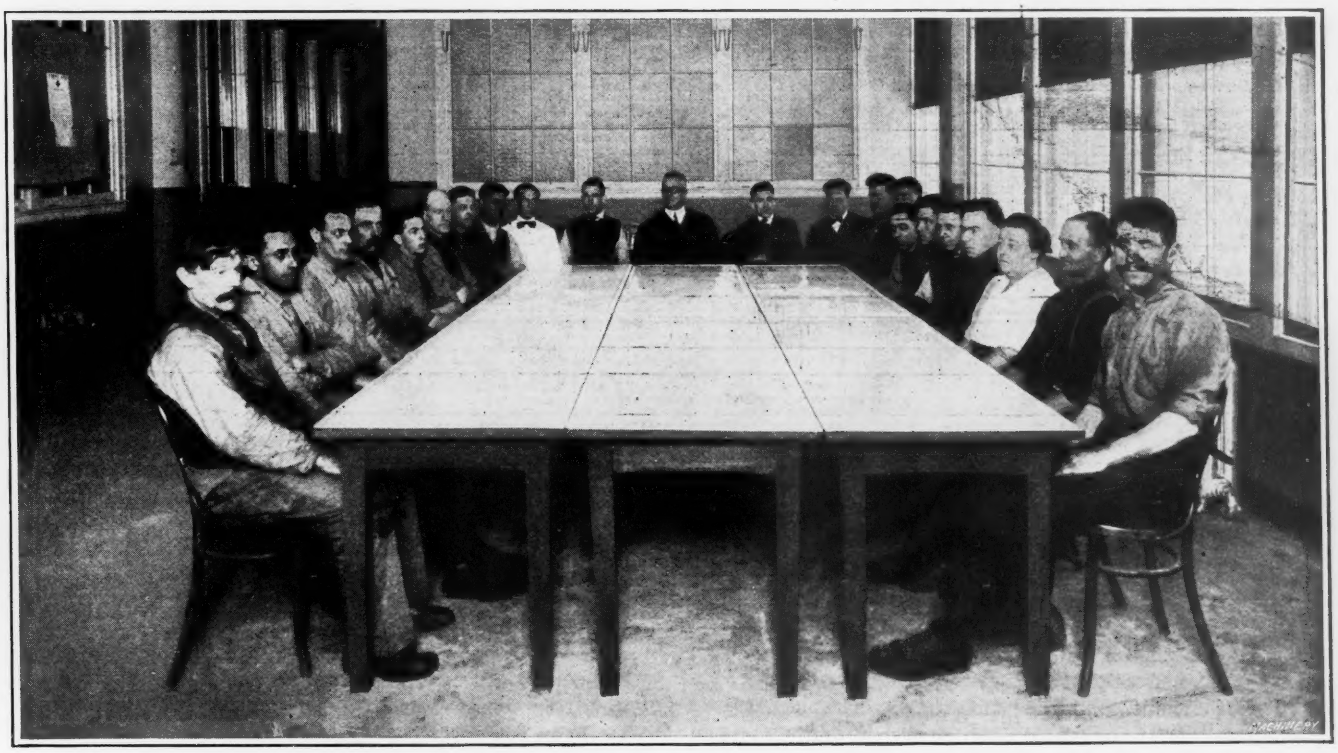


Fig. 2. The Legislature in Session. The Legislature consists of the Elected Representatives of the Workers

Power and Duties of the Judiciary

The judiciary, which is composed of the foremen, assistant foremen, and department heads, sifts the suggestions made by the legislature and makes further recommendations, if necessary, to the executive council. Members of the judiciary may also introduce suggestions and recommendations for the consideration of that body and for further submission to the executive council. The judiciary elects a president, vice-president, and recording secretary at its first regular meeting in June, the same as does the legislature. The meetings of the judiciary are held twice a month, except if a special meeting is called by a two-thirds vote of its members. Attendance at the meetings is restricted to the members of the judiciary body, but the chief executive or members of the executive council may be present with privilege of taking part in the discussion, but with no power to vote. The industrial relations manager is a member of all committees of the judiciary, the same as in the legislature; he attends all meetings, and has the privilege of taking part in all discussions but is not given the power to vote.

The Executive Council and the Chief Executive

The executive council, composed of the factory manager, the superintendents, and general foremen, considers the suggestions received from the two lower bodies and refers them to the chief executive with their recommendations. The members also consider recommendations made by the chief executive and suggestions submitted by one of the members of the council for the consideration of the other members of that body. The chief executive has the power to veto any recommendation passed to him, in case he finds it necessary. He has not been required to exercise this power, however, because all proposals so far on which there has been a disagreement between the legislature and the judiciary, have been agreed upon by a joint conference committee of these two bodies before the propositions have been passed to the upper bodies.

Annual Meeting of the Employes

At the general annual meeting of the employes, when representatives are elected to the legislature for the various departments, all other matters of mutual interest to the employer and the employes are discussed, and recommendations

and resolutions are offered which the representatives later will take up with the management. Matters are also submitted by the members of the executive council or by the chief executive for the consideration of the employes, and a vote is taken. Reports of the various committees, indicating their activity during the past year are also presented. This meeting is presided over by the officers of the legislature.

In order to bring the representatives of the workers into more direct contact with the executives of the firm, meetings are also held twice a year, presided over by the chief executive, at which the executive officers of the firm, the executive council, the members of the judiciary, and the workmen's representatives in the legislature are present.

The minutes of all meetings are carefully kept and copies are made by the industrial relations manager so that he has a complete record of all the minutes of every branch of the representative bodies or committees involved in this plan of representation.

The Committees and their Work

There are four standing committees which handle the greater part of the detail work of considering proposals made in the legislature and carry on all general investigation work required in connection with suggestions made. These are the joint committee on industrial cooperation and conciliation; the joint committee on safety and accidents; the joint committee on health, sanitation, and housing; and the joint committee on recreation, education, and insurance. Each of these committees is composed of six members, three of whom are designated by the judiciary and three by the legislature.

The committee on industrial cooperation and conciliation is by far the most important, because this committee deals with all questions pertaining to the prevention and settlement of industrial disputes, conditions of employment, reported grievances, appeals from discharge notices, and rules relating to the maintenance of discipline, etc.; in addition, it handles all questions relating to improved production methods, machinery required, etc.

The committee on safety and accidents, as the name implies, deals with matters pertaining to accidents and the safeguarding of machinery, fire protection, first aid, fire drills, etc.

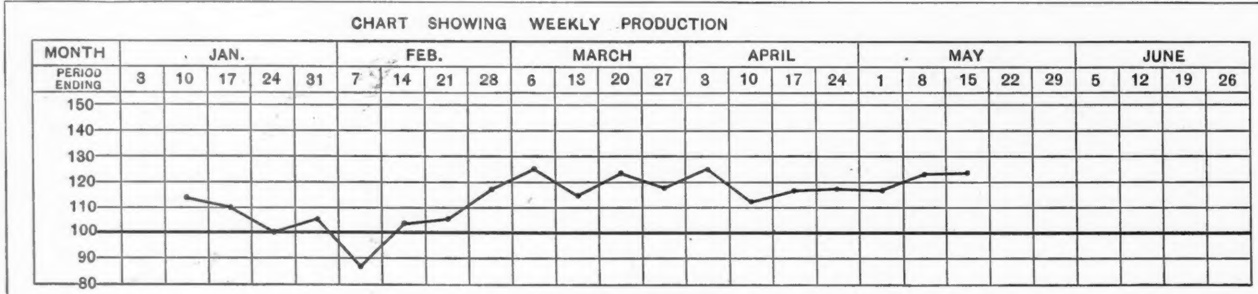
The committee on health, sanitation, and housing deals with all questions relating to physical examinations, medical treatment, sanitation, wash and locker rooms, rest rooms, drinking water, restaurant service, as well as housing problems.

The committee on recreation, education and insurance, as the name implies, deals with all questions pertaining to social activities, club houses, playgrounds, entertainments, moving pictures, athletics, schools, libraries, naturalization, technical education, manual training lectures, sick benefit, life insurance, etc.

The Plan in Operation

The organization required for a complete plan of workmen's representation has been given in considerable detail, so that manufacturers in general may be able to form an idea of the method by which the plan is applied in practice. The greatest general interest, however, will doubtless center upon the actual working of the plan, the questions that are considered, and the results that have been obtained.

Briefly described, the method of procedure when a member of the legislature wishes to make a proposal for adoption by the management is as follows: He introduces what is known as a "bill" in the legislature, in writing. If adopted, the bill is referred to the judiciary for approval. If approved by the judiciary, it is submitted to the executive council, and if approved by the council, to the chief executive. On the other hand, if the judiciary originates a bill it goes first to the executive council and then to the chief executive, who will refer the matter to the legislature in case he deems the subject one upon which the legislature's opinion would be of value; or, if the matter relates purely to a management problem, he will decide without referring to the legislature.



MONTHLY RECORD

MONTH	JAN.	FEB.	MARCH	APRIL	MAY	JUNE
BASIC PERCENTAGE	100	100	100	100		
MONTHLY ACTUAL PRODUCTION PERCENTAGE	106.28	116.72	122.3	120.54		
PER CENT DIVIDEND ON WAGES	3.14	8.36	11.15	10.27		
TOTAL AMOUNT OF DIVIDEND, DOLLARS	1800	4400	7200	6200		

Machinery

Fig. 3. Type of Production Chart posted in the Plants to show the Average Weekly Production and to record Dividends earned

If the legislature makes a recommendation which is not approved by the next body, the recommendation is returned to the body from which it originated, together with further recommendations, after which it is reconsidered. If it is to be passed in its original form over the veto of the next succeeding body, it requires a two-thirds vote. For example, if a recommendation originates in the legislature, but is disapproved of by the judiciary, it will be returned to the legislature with a complete statement of the reasons for disapproval. The legislature then takes a second vote, and if two-thirds of those present vote in favor of the original recommendation, the matter is referred to a joint committee. Usually all differences of opinion are settled to the satisfaction of everyone concerned by the joint committee, but provisions are made for arbitration in cases of a tie vote in the committee. No such case has ever been met with in the experience of the corporation whose plan is here described.

The Suggestion Box

In order that all employes may have an opportunity to present suggestions for improvement either in the manufacturing methods or for the general comfort and welfare of the employes, suggestion boxes are provided in the plant, and special blanks are available upon which any employe may make suggestions. These suggestions are not signed, but the suggestion blanks are provided with a coupon having a number corresponding to the number on the blank. This coupon is torn off by the employe making the suggestion and

kept by him for identification. The suggestions are collected by the industrial relations manager, who prepares copies, one of which is filed for permanent record and the others handed over to the permanent committee having charge of that part of the work to which the suggestion pertains. The clerical work is handled by the industrial relations department, and careful records are kept of all suggestions made and the actions taken upon them. Sometimes the suggestions, instead of being passed to a committee, are referred directly to the legislature, and in some cases they may be referred directly to the executive council or the chief executive, according to the nature of the suggestions.

Every suggestion and every bill is kept in a special envelope carrying a consecutive number and giving the date when it is received by the industrial relations manager. The envelope also has upon it a printed form giving the date when it is referred to one of the standing committees, the legislature, the judiciary, the executive council, or the chief executive, as the case may be, and has also upon it spaces for recording whether the action taken by any of these bodies was favorable or unfavorable, and whether an award was recommended. The award refers to a special compensation being made for suggestions considered valuable. Substantial awards have been recommended and paid in many instances for suggestions of a constructive nature. Many suggestions, of course, are of a nature to call for no award, although they may be acted upon favorably. Announcement is made on the bulletin boards whenever a suggestion has been finally acted upon, whether it be a favorable or an unfavorable decision. The number of the suggestion blank is given, and by means of the coupon corresponding to this number, the employe having made the suggestion may claim the award.

How Does the Plan Work out in Practice?

Most of the employers unacquainted with the results obtained by workmen's representation fear that the proposals made by the representatives of the men may be of such a nature that it would be impossible for the management and the representatives of the employes to agree, and that instead of creating harmonious feelings, a state of friction and dissatisfaction might be the result. The experience of the Greenfield Tap & Die Corporation indicates that no such fears need be entertained. The majority of the employes in any factory when given the responsibility of expressing themselves as representatives of the whole body of workers will be found to be reasonable and conservative. There has been no question brought up during the past year upon which a satisfactory settlement to all concerned has not been found possible. One of the proposals dealt with during the year, and doubtless the most important of all that was handled, has been the question of working hours. The legislature proposed a reduction of working hours from fifty-five to forty-eight, but upon representation made to the legislature by the management of the corporation, a compromise of fifty hours per week—nine hours for five days and five hours on Saturday—was reached. It was made a condition of this arrangement that the employes should make a special effort to increase their production so that within a given period, the production in fifty hours should equal the production in fifty-five hours. Not only was this condition met, but as will be referred to later, due to a special incentive of increased compensation, the employes have through their efforts been able to increase production materially, even beyond the past production in fifty-five hours.

In another instance, a question of piece rates came up in the legislature. One employe asked to have the piece rate on a certain performance upon which he worked, increased. The committee appointed to investigate the matter found that the increase was reasonable. A recommendation to that effect was made and approved by the management. Later, the same man requested an increase in piece rates on some other operation that he performed. At this time the representatives of the employes made an adverse recommendation, stating that they thought the piece rate as set was satisfactory. This indicates that the representatives will take a reasonable view of things when they are given the responsibility of going definitely on record with their decisions.

Actual Questions Dealt with by the Legislature

In order to indicate to employers interested in installing a system of this kind in their plant what the questions are that the representatives of the employes are most likely to bring up, a review is given of the questions handled at the meetings of the legislature during three consecutive months. It will be found that questions relating to heating occupied a fair proportion, due to the fact that the three months selected were winter months. At the meeting of the first month, a new member was appointed to one of the standing committees; a recommendation was made to change the payday from the present day in the week to Saturday; a recommendation was made for improved heating facilities for certain departments; and the conditions in the locker-room were discussed and certain recommendations made.

At the meeting the following month heating conditions were again discussed, and a plan was proposed for preventing draft through the door by which steel coming into the factory was trucked and unloaded. Previous to this meeting membership in the employes' association was permitted only to employes who had been continuously employed for three months, and as only members participate in the dividends paid as a result of increased efficiency, it was recommended that membership should be extended to include all those who had been in the employ of the company one month, giving them a chance to participate in the dividends. This recommendation was later approved by the management. It was further proposed by the workmen's representatives that if an employe was late more than twice during any one month, he should lose twenty-five per cent of his dividend for each time of lateness in excess of the minimum of two times allowed. This recommendation was passed by the legislature, but on recommendation of the chief executive it was later rescinded.

At the meeting of the third month the following questions were dealt with: The keeping of an alley clear from trucks and boxes; the providing of a truck for the exclusive use of the tool-room; an investigation into the reason for the falling off in production at a time when the men felt that they were working as hard as ever; and a proposal for the establishment of a cooperative store. The proposal with regard to the cooperative store was approved by the upper bodies and the chief executive, and it has been decided to start this enterprise. The firm will finance the undertaking and will also pay the overhead, so that the men will be able to buy actually at cost. The employes recognize that an opportunity to buy at reasonable prices is more valuable than a flat increase in wages, because an increase in wages would soon be absorbed by the increased prices that storekeepers would be enabled to charge, whereas cheaper goods bought in the cooperative store give permanently a greater value to the wages earned.

As will be noted, none of these proposals show any radical or unreasonable tendencies, but on the contrary, they indicate a disposition on the part of the employes to cooperate with the management of the firm for the best interest of the welfare of all concerned.

How the Standing Committees Investigate Problems and Aid in Establishing Cordial Relations

In order to show how the standing committees, through their investigations and recommendations, are an actual help to the management, it may be of interest to note a few of the problems that they have handled. During one month the committee on industrial cooperation and conciliation dealt with questions relating to piece rates; a proposed mechanical improvement eliminating two operations in performing a certain class of work; desirability of installing two new machines for one department; better artificial

lighting facilities for certain work; installation of a system for handling certain matters in the shop; the distribution of pay slips; requisition of blanks; and in addition three other mechanical improvements for increasing the shop efficiency.

The committee on health and sanitation dealt with such questions as heating conditions; the providing of special ventilating windows; the reduction of drafts in certain parts of the factory; certain improvements in the restaurant; racks for girls' clothing; improvement in the lighting systems; conditions of the rest room; and many similar problems.

The safety and accident committee dealt with questions relating to guarding the switches on motors; wooden pulleys in poor condition; the guarding of grinding wheels; the providing of handles on elevator cables; the covering for electric wires, etc.

The committee on recreation, education and insurance dealt with certain phases of the work of the employes' benefit association and group insurance, and with various details relating to recreations and amusements.

The Results Obtained

The main question after all is: What are the results in the Greenfield plants? Here is an elaborate piece of machinery requiring considerable clerical work and attention on the part of the management and considerable thought, interest, and effort on the part of those employes who are elected to represent their fellow-workers. What are the benefits to be derived from this method, and are the benefits accruing to the management alone, or to the workers alone, or are they mutual? The answer given at the Greenfield Tap & Die Corporation's plant is that the results are definite and that the advantages gained accrue to employer and employe alike. There has been a material increase in production as compared with the period before the introduction of the plan, especially in the larger plants operated by the corporation; and as the workers share in the form of dividends in the increased production, their net earnings have been increased proportionately. In one of the plants operated by the corporation during two successive months, the employes received over 10 per cent of their earnings during the month in the form of dividends. An incentive has been created, and the men in the shop can see that their interest and that of the firm can be promoted simultaneously. They show a greater interest in their work and are interested in improvements that eliminate waste. They are satisfied with the general shop conditions because, within reasonable limits, they are given a free hand in creating those conditions.

Permanent Record of Production

In order to keep the results obtained in the plant permanently before the eyes of the workers, and to stimulate their efforts in earning for themselves as big dividends as possible, a chart along the lines of that shown in Fig. 3 is kept for the workmen's inspection in each of the plants controlled by the corporation. The base line 100 indicates normal production. The curve shown indicates from week to week whether the production in the plant is above or below normal. It will be seen that during one week the production fell below normal, while the general tendency is for the production to be from 15 to 20 per cent above normal. If the average production rises to 20 per cent above normal during any month, one-half, or 10 per cent of this, is credited directly to the workers, and they receive at the end of the month a dividend of 10 per cent on their wages. On the bottom of the chart is a monthly record which gives the basic percentage, the actual average percentage of production achieved during the month, the percentage of the dividends on the wages, and the total amounts of dividends paid in dollars. This chart and the figures given have proved to be of great value in keeping the men informed as to actual production of the plant and in stimulating their interest in increasing production.

Conclusions Drawn from the Experience of the Greenfield Tap & Die Corporation with Workmen's Representation

The opposition generally found to workmen's representation is in most cases due to a misunderstanding of the application of the principle. Much has been said and written in opposition to this method by those who have not tried it and whose information upon the subject has been incomplete. It is not proposed in any plan of workmen's representation to turn the actual management of the plant over to the employes; that would be impossible, and 95 per cent of the toolmakers and machinists in our metal-working industries know that such a scheme would result in failure. But what the employes appreciate is a chance to be permitted to have something to say about the actual conditions under which they work and to be assured of a share of that part of the increase in production that can be traced directly to the increased effort, interest, and energy, which they display where their cooperation has been enlisted by methods such as outlined. This has been the experience of the Greenfield Tap & Die Corporation, and the facts presented in the foregoing are merely intended to record the methods and the results obtained in a plant in the tool manufacturing field where the workmen's representation plan has been fairly tried.

* * *

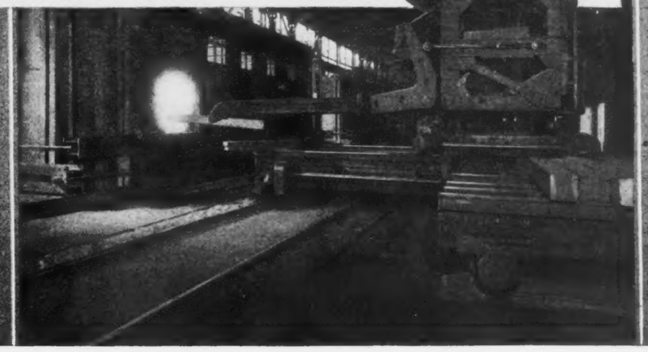
COMPARISON OF HARD AND SOFT SNAGGING WHEELS

The following interesting data concerning the relative merits of hard and soft grinding wheels for snagging steel castings and high-speed steel billets were published by the Norton Co., Worcester, Mass., in a recent issue of *Grits and Grinds*. In a test on open-hearth steel castings, a wheel 18 inches in diameter was used, both sides having a 3/4-inch taper. The labor was employed at piece-rate, and the overhead cost was $1 per hour. Two standard Norton alundum vitrified wheels were used in the test, the softer of which, 6610-U 0115, showed an average life of 47.5 hours. The hard wheel, 6610-W 0115, showed an average wheel life of 100 hours, yet the total cost per ton including overhead expense was $4.91, as compared with $4.16 for the soft wheel. The fact that the wheel life was increased more than 100 per cent with the harder wheel and yet that the grinding cost was greater than with the soft wheel is due to the slower cutting of the harder wheel, the result in pounds of castings ground per hour for each wheel being 874 for the soft wheels and 700 for the hard wheels.

Two tests were made on high-speed steel billets, each test being run with a different grain of alundum vitrified Norton wheels, 14 inches in diameter. The labor cost on one of these tests was 43 cents per hour and the overhead cost $15 per day. The softer wheel, grain 20, grade R, showed an average wheel life of 39 hours, grinding away the steel at the rate of 2.21 pounds per hour, while the hard wheel, grain 20, grade U, showed better results as regards wheel life, the average number of hours being 60, but the amount of steel ground off was only 1.32 pounds per hour. Thus, although the life of the softer wheel was only 65 per cent that of the hard one, the total grinding cost was reduced about 30 per cent due to the increased hourly production. The total cost per pound of steel ground off on the two wheels was 61 cents and 85 cents, respectively.

In making the other test on the billets, the labor was employed at piece-rate, and the overhead expense was 90 cents an hour. Norton 20-R and 20-W wheels showed the following results: 22 hours, average wheel life of the 20-R, or soft wheel, as against 61.2 hours on the hard wheel; steel ground off per hour 4.1 and 2.4 pounds per hour, respectively; total cost per pound of steel ground off 43 cents and 57 cents, respectively. These data show that by reducing the wheel life practically one-third and using a softer wheel, the actual grinding cost was reduced 14 cents per pound of steel removed.

Manufacturing Seamless Steel Tubes



Practice of the National Tube Co., Pittsburg, Pa., in Producing Shelby Seamless Steel Tubes, Including the Processes for Hot-finished and Cold-drawn Tubes and the Manufacture of Large Tubes and Seamless Cylinders

THE first and one of the most essential steps connected with the manufacture of seamless tubing is the production of a uniform, homogeneous steel of the right physical and chemical properties. The manufacture of the steel used for making Shelby seamless tubing is controlled entirely by one organization to insure uniformity and a continuation of these uniform qualities. This steel, as delivered to the heating furnace, is in blooms about 11 feet long and usually from 6 to 10 inches square. After these blooms have been carefully inspected for surface defects and any irregularities removed with pneumatic chipping hammers, they are placed one at a time in a heating furnace by an electrically operated charging mechanism (see the heading illustration). This heating is preparatory to the rolling operation.

Rolling the Blooms into Round Bars or Billets

When the proper temperature for rolling has been reached, the bloom is pulled from the furnace by the long arm of the crane or transfer mechanism and placed upon a small electric buggy; this buggy transfers it to the rolling table of the bar mill where it passes through a series of rolls which changes the square bloom into a round bar or billet of smaller size and greater length. Different sizes of round bars are rolled according to the size of tubes required to be made from them; some of the bars are 8 inches in diameter when finished, and others are as small as 3 inches. While still at the rolling heat, the round bars are cut to different weights (according to the length and wall thickness of the finished tube) by a circular saw, and centered while still hot. They are then allowed to become cold, after which they are inspected, marked with a die to identify the steel, and sent to the piercing mill.

Centering the Billets

The billets, or "rounds," contain just enough metal for making tubes of the desired length, thickness, and diameter, and to compensate for normal losses incident to manufacturing the tube. The first operation in making a seamless tube from the billets is known as "centering." This is performed by a pneumatically operated machine, as shown in Fig. 1, while the billet is still hot from the rolling mill; an indentation is made in the center of one end of the billet by a punch, in much the same manner as preparation is made for drilling holes in metal by center-punching. The cavity or countersink thus produced, which is about 1 inch deep, insures proper starting of the hot billet in the piercing operation, permits insertion of the piercing point at its most effective position in relation to the piercing rolls, and makes for an equalized displacement of metal from the center of the billet.

How Rough Seamless Tube is Formed in Piercing Mill

After the billets have been centered, inspected, and marked, they are placed in a heating furnace of special construction. The bottom of the furnace is inclined, and centered billets of the proper length are fed into the upper and cooler end, from which they roll by gravity to the lower end, where the temperature is high enough to render the steel semi-plastic.

The piercing mill is located close to the discharging end of this furnace and the billets are fed into it, centered end foremost, as in Fig. 2. The solid billet, almost white hot,

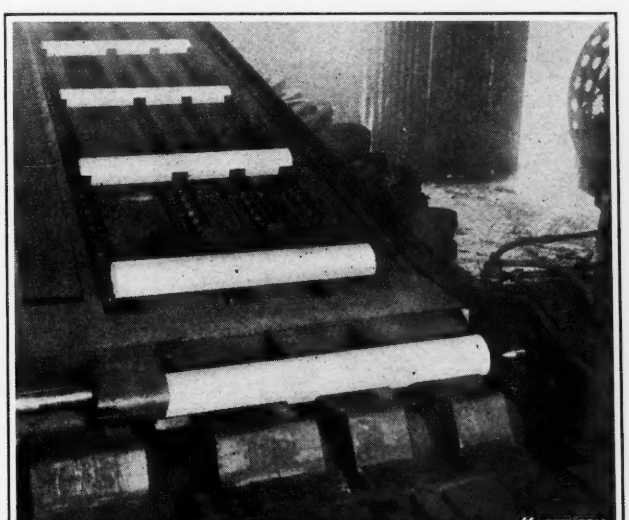


Fig. 1. Pneumatic Centering Machine for centering One End of the Hot Billet preparatory to the Piercing Operation

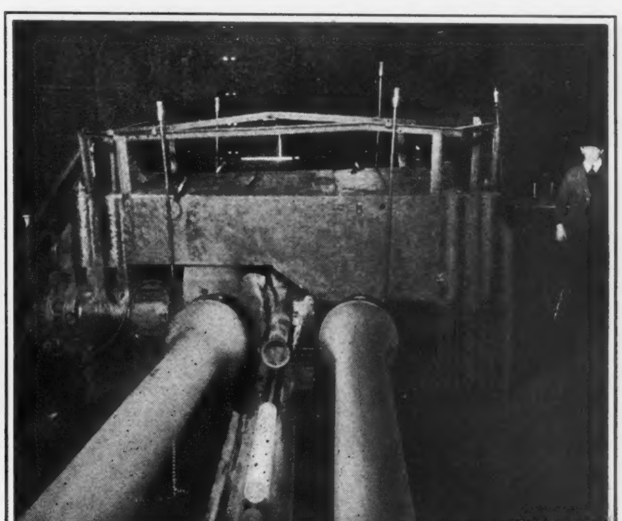


Fig. 2. A Heated Billet entering the Piercing Mill where the Centered End is forced over the Piercing Point of a Mandrel

is pushed forward until it is caught by the revolving rolls of the piercing machine, which force it over the piercing point of a mandrel as illustrated by the diagram Fig. 5. As the billet is forced over this bullet-shaped point by the combined forwarding and rotating action of the heavy revolving rolls, a dull, grinding sound is audible. While enormous force is required to operate the piercing machines, there is nothing spectacular about the operation, nor is there much suggestion of the enormous power required to displace the metal from the center of the hot billet toward the outside. The newly pierced billet at this stage in the process is simply a rather rough, thick-walled, seamless tube. It is raw in appearance and not particularly true to size, and it retains the knurl marks of the piercing rolls on its battered surface. But it is without seam or weld, the round bar of steel having been pierced throughout its length.

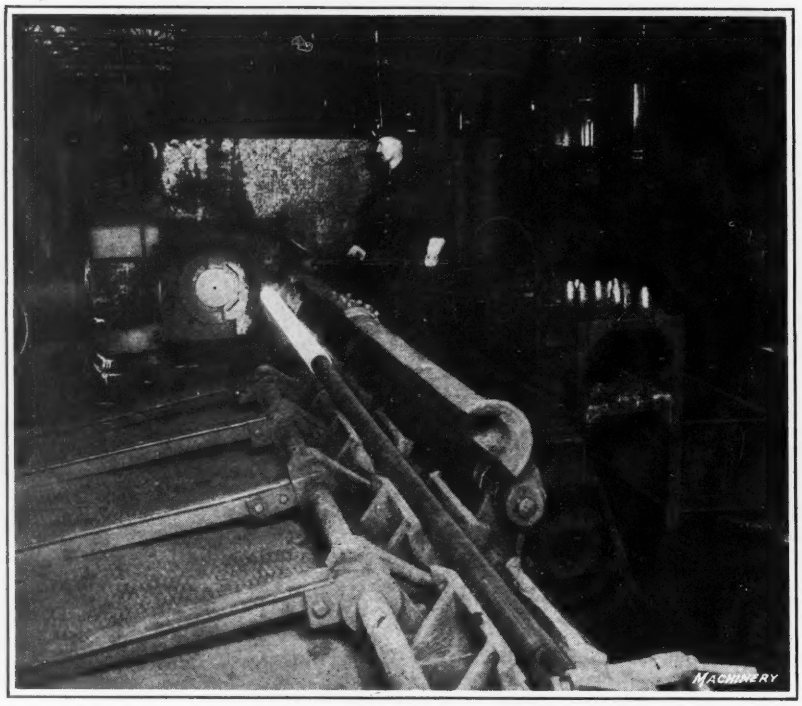


Fig. 3. Rough Tube coming through the Piercing Mill

Lengthening Tube and Reducing Diameter by Rolling

The tube at this point is short and has thick walls, and to change this thickness into length is the next requirement. Accordingly, it is rolled through adjustable rolls and over a mandrel held in the roll groove by a long steel bar, where the wall thickness and diameter are reduced, and in this manner it is converted into a longer tube with walls of uniform thickness having a fairly smooth finish. This operation is illustrated in Figs. 4 and 6.

While still at a suitable working temperature, the rolled tube passes on through the reeling machine shown in Fig. 8. This is another form of rolling machine, consisting of two heavy rolls of special design, set with axes askew, which may be adjusted to a thousandth of an inch. (See the diagram Fig. 7.) As the tubes are fed through these rolls, any mill scale is removed, a smooth, burnished surface is produced, and the outside diameter of the tube is corrected to some extent. From the reeling machine, the tubes pass to the sizing or finishing rolls Fig. 9, which reduce the outside diameter to exactly the required size.

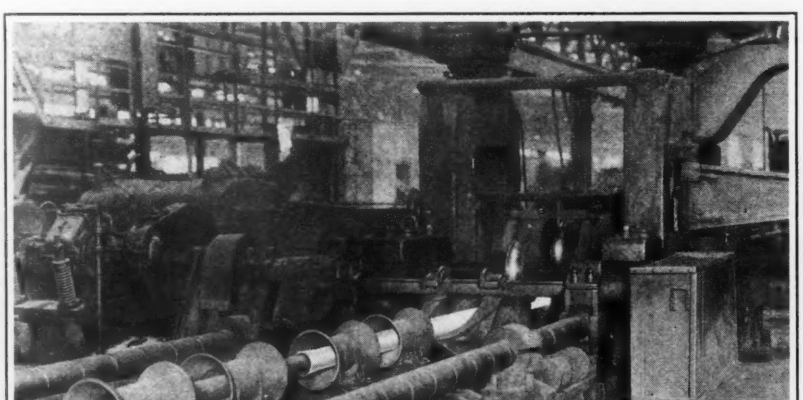


Fig. 4. Rolling Mill which lengthens the Rough Tube and reduces its Diameter

Cooling the Tubes, and Trimming and Cutting to Length

From the finishing rolls, the tubes travel to an inclined cooling table, Fig. 10, up which they are rolled slowly by conveyor chains, and after being sorted and inspected they are put into racks, ready for removal by electric cranes. The electric cranes transfer the hot-finished tubes to cutting-off machines where the rough ends are trimmed from the tubes and the tubes cut to proper length. Any slight straightening necessary is then done, the tubes are thoroughly inspected (if boiler tubes, a hydrostatic pressure is also applied), after which they are stencilled. They are then put in stock or sent to the shipping room.

Tubes which have passed through the operations described up to this point are known as hot-finished tubes. The term "hot-finished" is used to distinguish these tubes from hot-rolled tubes which are intended for cold-drawing to smaller sizes. When tubes are hot-finished, they are ready for use without further treatment in the mill, and all operations are performed on the tube before it becomes cold, thus differing from the manipulation of cold-drawn tubes, which are allowed to become atmospherically cold before reaching the draw-benches.

Cold-drawing Seamless Steel Tubing

Hot-rolled tubes that are to be cold-drawn are given the same piercing, rolling, reeling, and sizing operations as tubes that are to be hot-finished. The first operation preliminary to cold-drawing is pointing the tubes. One end of each tube is heated and then pointed in swaging dies under a power hammer. Pointing the tube furnishes a "bait" which is grasped by the heavy tongs of the draw-bench in which the tube is to be cold-drawn.

Before tubes can be cold-drawn they must be clean and free from mill scale. They are therefore pickled in an acid bath, which is heated and kept in constant agitation by jets of steam. While the operation of cold-drawing is simple in principle, expert mechanical supervision is necessary to secure uniform, accurate results. The operation is practically the same for steel tubes as it is for brass and copper tubes. The apparatus used consists of a heavily constructed steel draw-bench, in the center of which is the die through which the tube is to be drawn. A heavy, square-linked endless chain runs over a wheel located underneath the die, and travels along the top of the bench for a

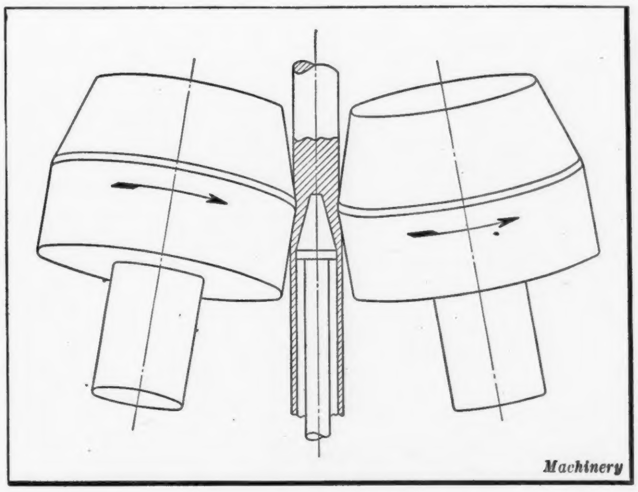


Fig. 5. Diagram of Piercing Operation showing the Revolving Rolls of Piercing Machine and End of Mandrel over which Billet is forced

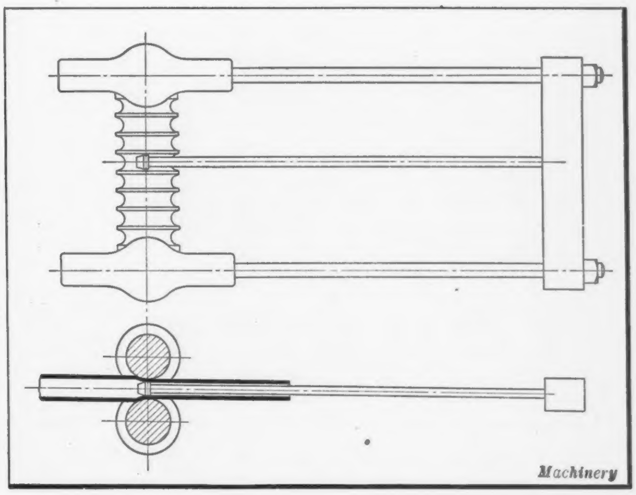


Fig. 6. Diagram of the Rolling Operation for reducing the Wall Thickness and Diameter of the Tube after a Piercing Operation

distance of from 15 to 40 feet to a sprocket which is geared to a suitable source of power. The chain returns underneath the draw-bench.

Operation of a Draw-bench

In operation, a hot-rolled tube (now perfectly cold) is partially inserted in the die with its pointed end projecting through as shown in Fig. 11. A workman slides a mandrel into the tube from the opposite end, and an operator seizes the pointed end of the tube with heavily constructed tongs which run on wheels along the bed of the draw-bench. (See Figs. 12 and 13.) The tongs have a strong hook that catches on the traveling chain. By a tremendous pulling force the tube is drawn or literally squeezed through the die, or between the die and the mandrel previously inserted. All tubes except those of ½-inch inside diameter and less, and those in which the wall is very heavy relative to the diameter are drawn over mandrels. The mandrel is kept in position by a long bar which goes inside of the tube and holds the mandrel just even with the die while the tube is being drawn. Dies are made from the very best grade of crucible steel, and are machined to a thousandth inch, to govern the outside diameter of the tube that is to be drawn. Shelby seamless steel tubes are drawn from two to twenty times through dies of varying diameter to obtain the required dimensions; some tubes are drawn still more by the manufacturing consumer.

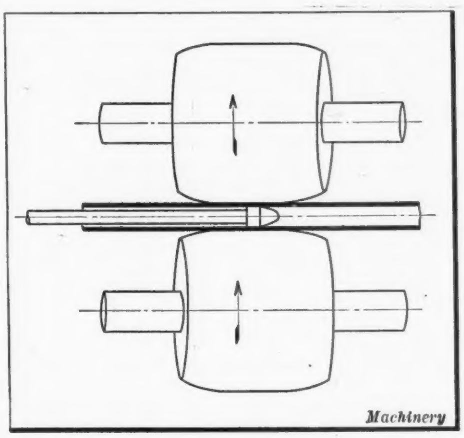


Fig. 7. Diagram of Reeling Operation, showing Rolls which are inclined to each other and the Central Mandrel

Annealing the Tubes

After the tube receives the final pass through the dies, which reduces it to the desired outside diameter and thickness, the point is cut off and the tube passes to the annealing furnaces. Cold-drawing makes the tube hard and brittle, and therefore after each cold-drawing pass it is necessary to anneal the tube in order to make it soft enough to withstand further drawing. The process of annealing forms scale on the tube, which must be removed by pickling; otherwise the scale would scratch the tube and score the die on subsequent cold-drawing passes.

After the last cold-drawing operation, the tube is subjected to one of various anneals, according to the use for which it is intended. This anneal may vary from a "light" anneal to remove drawing strains, to a "long" anneal in a closed box ("retort anneal"), which makes the tube extremely ductile.

Straightening and Cutting to Length

After the required anneal has been given, the cold-drawn tube passes to the straightening machines, where any deviations from straightness are corrected. These straightening

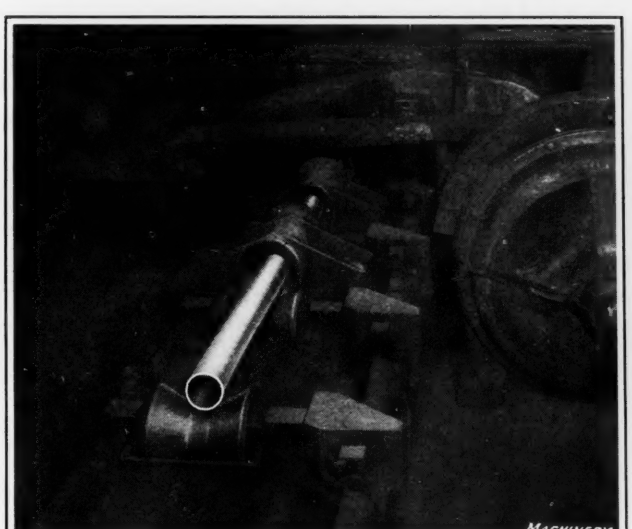


Fig. 8. Rolled Tube entering Reeling Machine equipped with Rolls for removing Mill Scale and partially correcting Outside Diameter

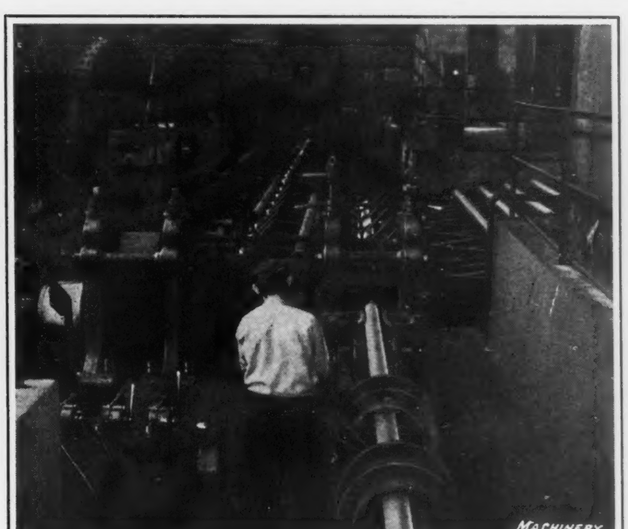


Fig. 9. Reheated Tube passing through the Sizing or Finishing Rolls which give the Exact Diameter Required

machines are of different types; some of them are based on a planetary system of roll-rotation, others consist of horizontal and vertical rolls together, and still others are nothing more nor less than presses designed for the purpose. In the two first-mentioned types, the straightening of the tube is practically automatic, while the human element enters to some extent in straightening tubes with the press type of machine. Small tubes are sometimes straightened by hand in a bending rack, the workman's eye and expert judgment being the main factors in securing the result.

Fig. 10. Cooling Table receiving Tubes from the Sizing Rolls

After leaving the straightening machine, the tube passes to a cutting-off machine where it is either cut to specified lengths or multiples, or to the best advantage in random lengths. When this has been accomplished, the tube (if for mechanical purposes) is given a final inspection and sent to the stock rack or shipping room.

Fig. 11. Pointed Tube projecting through the Die of a Draw-bench used for the Cold-drawing Operation

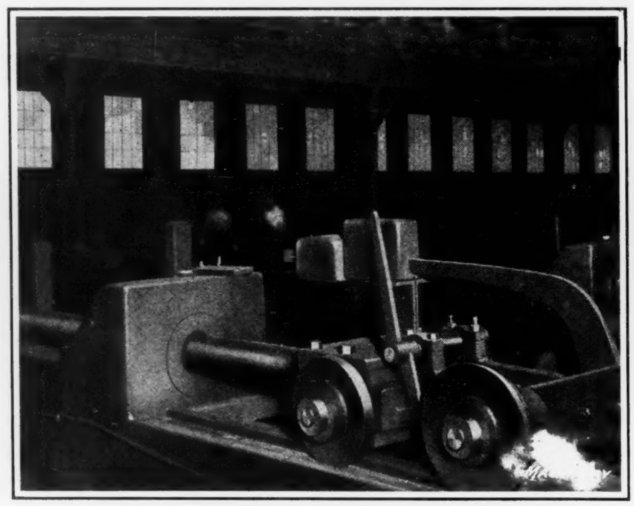


Fig. 12. Tongs of the Draw-bench pulling a Tube through the Die, illustrated diagrammatically in Fig. 13

Hydrostatic Tests

Seamless steel boiler tubes are given an internal hydrostatic pressure test immediately after they leave the cutting-off machines and have been inspected. The test pressure applied to tubes under 5 inches in diameter is 1000 pounds per square inch, and for tubes 5 inches in diameter or over an internal hydrostatic pressure of 800 pounds per square inch is employed, provided the fiber stress corresponding to these pressures does not exceed 16,000 pounds per square inch. In certain cases where the fiber stress is over 16,000 pounds per square inch, tubes of standard thickness over 6 inches in diameter are tested to 500 pounds per square inch at the mill. After the tubes have been fully tested they are marked with a stencil, showing the name of the manufacturer, the test pressure used, the kind of material of which the tube is made, and how it is finished. Tubes intended for mechanical purposes are tested differently from those used for boiler tubes. All tubing is subjected to frequent and rigid inspections and tests.

Drawing Seamless Steel Tubing from Flat Plates

Seamless steel tubes, in diameters up to and including 5½ inches, are made by the piercing process described in the foregoing; tubes 5½ inches to 9¼ inches can be made by either the piercing or the cupping process, while for tubes larger than 9¼ inches the cupping process is generally employed. By the cupping process, large, heavy-walled tubes are made from square plates of steel. It will be readily comprehended that to obtain a seamless tube, say 20 inches in diameter, from a solid billet of steel, would necessitate the use of rolling and piercing machinery of gigantic and unwieldy proportions, and to drive such machinery would require tremendous power, but a tube 20 inches in diameter is seldom required in lengths greater than 10 feet, and for such lengths the cupping process obviously can be more economically and advantageously employed.

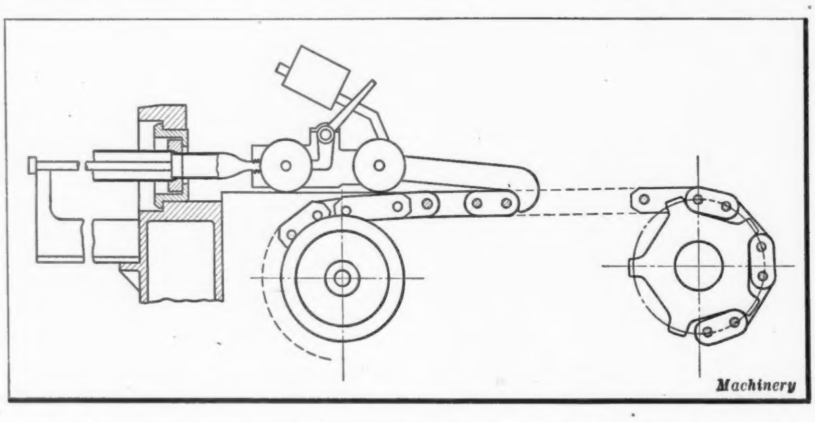


Fig. 13. Diagram illustrating the Arrangement of the Draw-bench with its Traveling Chain, Tongs, and Die

Cutting Circular Disk and Drawing Shallow Cup

The steel plates from which these larger tubes are made contain the calculated volume of metal required for

Fig. 14. Hot-punching Round Disks from Square Plates

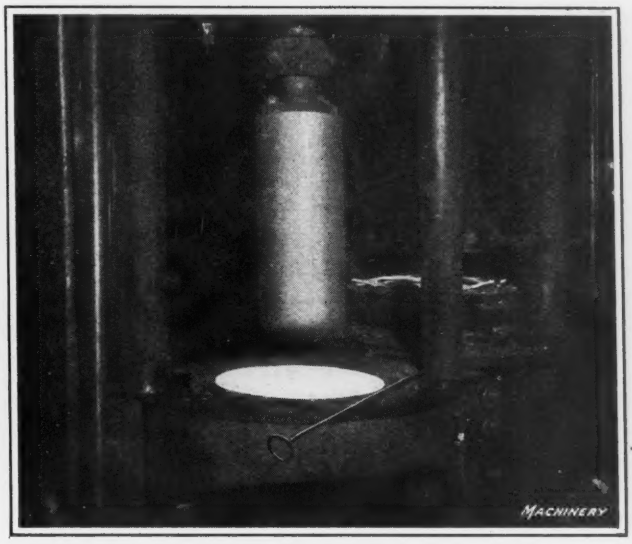


Fig. 15. Converting a Flat Disk into a Shallow Cup

the finished tube, plus a sufficient amount to compensate for the normal losses in manufacture. They are made from the same grade of steel as the billets for the smaller sizes of tubing, and are delivered to the heating furnace in squares varying in thickness from 3/8 inch to 4 inches, and in size from 2 to 7 feet square.

The square plates are placed in a heating furnace, and when they have reached the proper temperature they are withdrawn, and round disks are cut out in the press shown in Fig. 14; these hot disks are immediately passed to the hydraulic press, Fig. 15, where they are forced through a die, thus forming a rough shallow cup; these cups are again heated and pushed through a smaller die, Fig. 16, which elongates them and reduces the diameter.

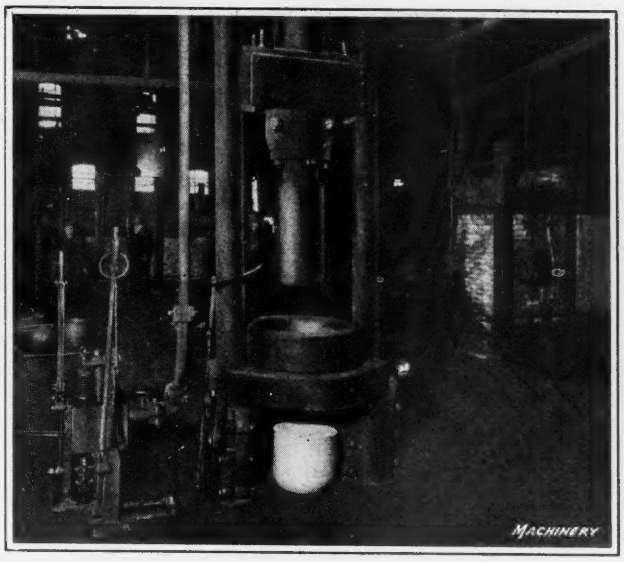


Fig. 16. Second Cupping Operation for reducing the Diameter and elongating the Cup

After a plate, or disk, has been formed into a cup of suitable dimensions, it is reheated and drawn through a series of dies in a horizontal bench. This apparatus, which is shown in Fig. 17, consists of a heavy cast-steel frame or body, provided with a powerful hydraulically operated plunger which can operate through the full length of the bench. Punches of various sizes are placed on the end of the plunger, according to the size of tube desired, and dies of successively decreasing diameter are dropped in recesses in the bench frame in positions so that the heated elongated steel cup may be forced through them one after another by the punch. Inasmuch as the reduction of diameter and walls is limited for each heat, a cup may be heated and drawn as many as twelve times before it is a finished tube.

The plate has now passed into tubular form, and the original head, or the bottom of the cup, forms but a small portion of it. Subsequent hot-drawing operations may be

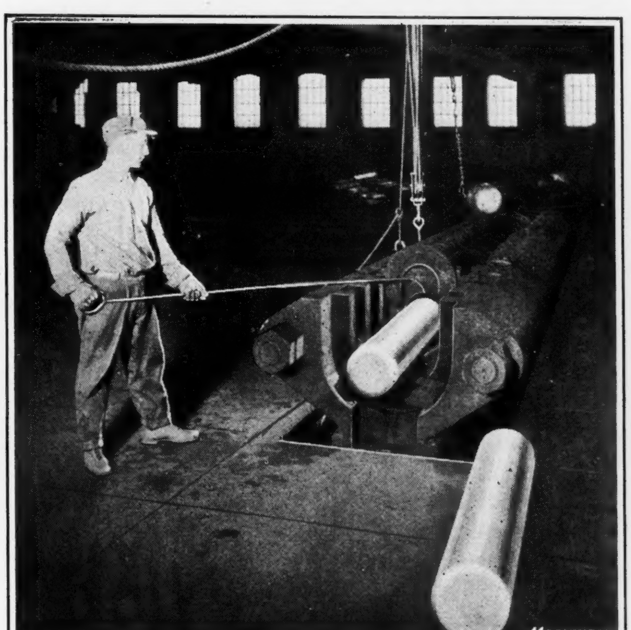


Fig. 17. Drawing Hot Cup into Seamless Tube in Series of Dies

Fig. 18. Dishing Ends of Seamless Steel Cylinders to form Bottoms

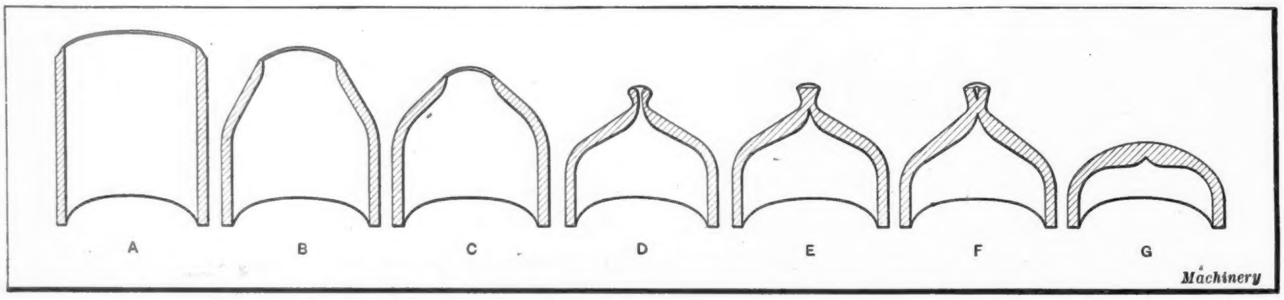


Fig. 19. Successive Stages in Spinning Operation for closing the End of a Seamless Cylinder

necessary to produce a tube with a smaller diameter, a thinner wall, or a greater length. Finally the head, or closed end of the tube, which remains until the last operation is completed, is cut off, the tube is inspected and tested hydrostatically and the process is finished. If the tube is to be used in making seamless steel cylinders, the head is left on to form the bottom of the cylinder, or a special type of head can be made by spinning, welding, or other operations.

Manufacture of Seamless Steel Cylinders

Seamless steel cylinders are used for containers of liquefied and nonliquefied gases, such as carbonic acid gas, hydrogen, oxygen, etc. To meet the varied requirements of different services, they are made in a wide variety of diameters, thicknesses, and lengths.

One method used in the manufacture of seamless steel cylinders, 6 inches in diameter or under, consists in cutting a piece of seamless steel tubing to the required length. The second step is forming a closed end on the tube by "spinning." The idea of spinning metal is old, but the adaptation of the spinning process in the seamless tube business, for converting tubes into cylinders, flasks, etc., is comparatively new.

In the spinning process, the open end of a tube can be closed and also perfectly welded in the same operation. The machine itself is a type of lathe with a hollow spindle provided with a chuck for holding the tubes to be spun. Before the tube is put in the spinning machine, the end to be spun is slightly heated. The spindle is then rotated at a high speed, with the tube. A blunt steel tool is brought to bear against the tube and swung around the end of it. Little by little the tool is brought forward at each sweep around the end, causing the tube to close up into a half-spherical form. The friction of this tool against the tube creates a high heat, and as the metal is gathered closer and closer toward the center the heat at the center becomes so intense as to melt the metal and close the opening with a perfect weld.

The different stages through which a spun end of a tube passes in this closing and welding operation are shown in Fig. 19. When the heat, in the judgment of the operator, is sufficient for welding, the tool is swept across the end of the tube, cutting off the projecting end shown in next to the last sectional view, and the welding of the center is performed, resulting in a closed tube end as shown at the extreme right. The power required to close a tube 6 inches in diameter by ¼-inch wall is about 40 horsepower.

As the majority of cylinders are required to stand on end, the half-spherical form of the tube end produced by the spinning operation must be re-formed to meet this condition. Therefore the tube is forced into a die, or matrix, of a press, which is so designed as to push the spun end inward or dish it, and change its form from convex to concave. This furnishes a level rim at the bottom of the cylinder upon which it may rest. The press used to "dish" the bottom of cylinders as described is shown in Fig. 18.

After the bottoms are formed, the cylinders are conveyed by an electric crane to the pickling tanks, where they are immersed in an acid solution to remove any mill scale from the interior. Upon removal from the pickling tanks, the open ends of the cylinders are raised to a forging heat and swaged under a power hammer to form a "bottle neck."

Heat-treatment and Hydrostatic Test

After the cylinders have been formed, they are heated in a continuous furnace, removed, and quenched in water. After this hardening process, they are removed to an annealing furnace and annealed, or drawn, to a degree which will make them ductile enough to withstand the flattening test required by the Bureau of Explosives' specification, and yet be strong enough to meet the high-pressure hydrostatic test. From the annealing oven the cylinders are again placed in a pickling bath to remove any scale that may have formed in the hardening furnace, after which they are placed in a lathe where the necks are trimmed off, bored, and threaded for valve connections.

When the threads of the cylinders have beeen inspected and gaged, the cylinders are given a hydrostatic pressure test. In this test, the cylinders are filled with water and lowered into a water-filled jacket, as shown in Fig. 20. The jacket is closed tightly and pressure is applied to the cylinder. This test serves a double purpose, as it proves the strength of the cylinder and serves to detect any permanent set in the walls after expansion under pressure. As the cylinder walls expand under the test pressure, the water in the jacket surrounding the cylinder rises and is indicated in a gage. Upon relieving the internal pressure of the cylinder, the gage connected with the water jacket indicates whether any permanent set has been produced in the cylinder.

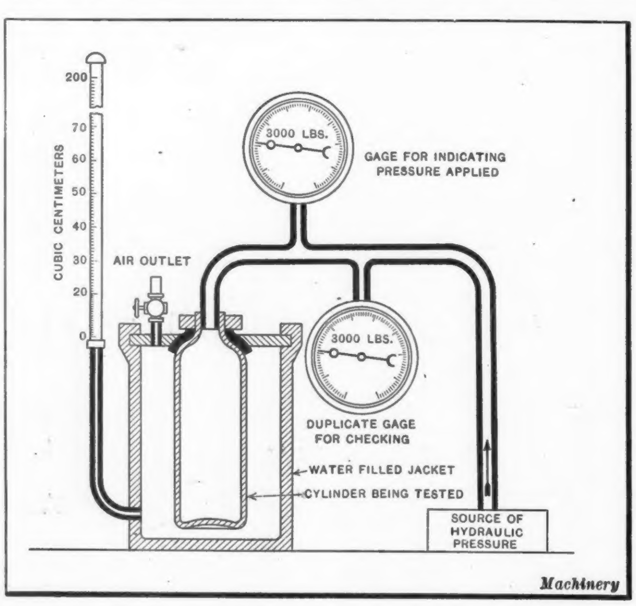


Fig. 20. Diagram showing Equipment for subjecting Cylinder to a Hydrostatic Pressure Test

The larger sizes of seamless steel cylinders (over 6 inches in diameter) are manufactured by the cupping process. The cupping process of making cylinders is identical with the process of making large hot-drawn tubes with the exception that in the manufacture of cylinders by this process, the end of the drawn cup is invariably used as the bottom of the cylinder, after being properly formed. After the plate has been punched into a cup and drawn into a tube, the open end is trimmed even and the cylinder is pickled, necked, heat-treated, finished, tested, and inspected.

Allowances and Tolerances for Screw Threads

Thread Standards of the National Screw Thread Commission, and the Tolerances and Diameters for Different Classes of Fits

THE National Screw Thread Commission was authorized by Congress, July, 1918, for the purpose of ascertaining and establishing screw thread standards for the use of manufacturers and various branches of the Federal Government. The aim of the commission in establishing thread systems has been to eliminate all unnecessary sizes and to utilize, as far as possible, present predominating sizes. Some of the terms used in this summary of the commission's report will be defined first to avoid any misunderstanding, especially in regard to certain of the terms which have not been generally used heretofore in connection with screw threads.

Definitions of Terms

Major Diameter—The largest diameter of the thread on the screw or nut. The term "major diameter" replaces the term "outside diameter" as applied to the thread of a screw and also the term "full diameter" as applied to the thread of a nut.

Minor Diameter—The smallest diameter of the thread on the screw or nut. The term "minor diameter" replaces the term "core diameter" as applied to the thread of a screw and also the term "inside diameter" as applied to the thread of a nut.

Pitch Diameter—On a straight screw thread, the diameter of an imaginary cylinder which would pass through the threads at such points as to make the width of the threads and the width of the spaces cut by the surface of the cylinder equal.

Angle of Thread—The angle included between the sides of the thread measured in an axial plane.

Helix Angle—The angle made by the helix of the thread at the pitch diameter, with a plane perpendicular to the axis.

Crest—The top surface joining the two sides of a thread.

Root—The bottom surface joining the sides of two adjacent threads.

Base of Thread—The bottom section of the thread or the greatest section between the two adjacent roots.

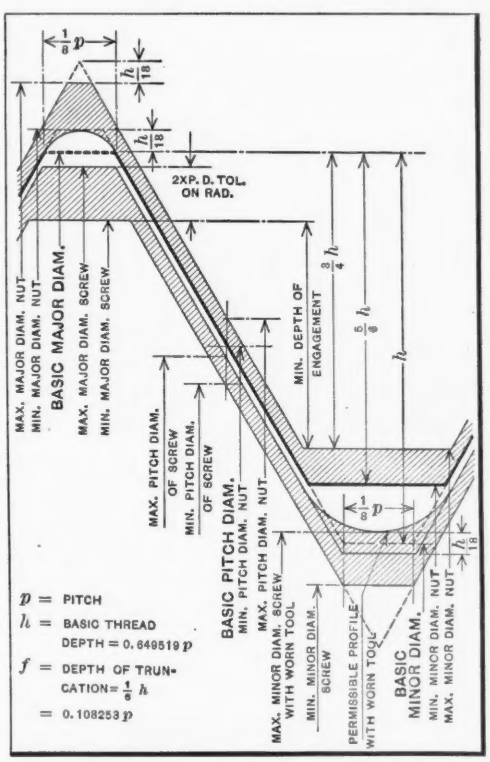


Diagram illustrating the Tolerances and Allowances for a One-inch Screw Thread of the Loose-fit Class

Length of Engagement—The length of contact between two mating parts, measured axially.

Depth of Engagement—The depth of thread in contact of two mating parts, measured radially.

Tolerance—A definite difference in the dimensions prescribed in order to permit of variations in manufacture. The "extreme tolerance" is the maximum and minimum tolerance permitted by the designer, the limits of which are to be placed on the drawings; it is the net tolerance as affected by the master gage tolerance. The "net tolerance" is the tolerance limits within which the product is ordinarily passed by the master gages; it is the extreme tolerance as affected by the master gage increment.

Basic—The theoretical or nominal standard size from which all variations are made.

Crest Clearance—Defined on a screw form as the space between top of a thread and root of its mating thread.

Neutral Zone (Allowance)—A space between the mating parts which must not be encroached upon.

Gage Increment—A predetermined allowance by which the net tolerance of the product is increased for gaging purposes.

Limits—Dimensions, the extremes of which are prescribed, to provide for variations in fit and workmanship.

Form of Thread Adopted by the National Screw Thread Commission

The form of thread profile that is recommended by the commission is known as the "National" form and is the same as the U. S. standard or Sellers profile. The National form is intended for all screw thread work except when otherwise specified for special purposes. A clearance is to be provided at the minor diameter of the nut by removing the thread form at the crest by an amount equal to from 1/6 to 1/4 of the basic thread depth. A clearance at the major diameter of the nut is to be provided by decreasing the depth of the truncation triangle by an amount equal to from 1/3 to 2/3 of its theoretical value.

National Coarse Thread Series

Specifications for what is known as the National coarse thread series are given in Table 1, which contains the numbered and fractional sizes and the basic diameters. This series contains certain sizes known previously as the U. S. standard threads and also certain sizes known as the A. S. M. E. machine screw threads. There are included in the National coarse thread series only those sizes that are essential. The National coarse threads are recommended for general use in engineering work, in machine construction where conditions are favorable to the use of bolts, screws, and other threaded components where quick and easy assembly of the parts is desired, and for all work where conditions do not require the use of fine pitch threads. The National (U. S. standard) form of thread profile is used for the coarse series.

National Fine Thread Series

The National fine thread series contains certain sizes known previously as the S. A. E. threads and also certain sizes known as the A. S. M. E. machine screw sizes. The fine thread series is recommended for general use in automotive and aircraft work, for use where the design requires both strength and reduction in weight, and where special conditions require a fine thread, such as, for instance, on large sizes where sufficient force cannot be secured to set properly a screw or bolt of coarse pitch, by exerting on an ordinary wrench the strength of a man. The specifications for the fine thread series are given in Table 2. The National (U. S. standard) form of thread profile is used for the fine series.

TABLE 1. NATIONAL COARSE THREAD SERIES

Numbered and Fractional Sizes	Number of Threads per Inch	Basic Diameters: Major Diam., Inches	Basic Diameters: Pitch Diam., Inches	Basic Diameters: Minor Diam., Inches	Metric Equivalent of Major Diam., Millimeters	Pitch, Inches	Depth of Thread, Inches
1	64	0.0730	0.0629	0.0527	1.854	0.01562	0.0101
2	56	0.0860	0.0744	0.0628	2.184	0.01785	0.0116
3	48	0.0990	0.0855	0.0719	2.515	0.02083	0.0135
4	40	0.1120	0.0958	0.0795	2.845	0.02500	0.0162
5	40	0.1250	0.1088	0.0925	3.175	0.02500	0.0162
6	32	0.1380	0.1177	0.0974	3.505	0.03125	0.0203
8	32	0.1640	0.1437	0.1234	4.166	0.03125	0.0203
10	24	0.1900	0.1629	0.1359	4.826	0.04166	0.0271
12	24	0.2160	0.1889	0.1619	5.486	0.04166	0.0271
¼	20	0.2500	0.2175	0.1850	6.350	0.05000	0.0325
5/16	18	0.3125	0.2764	0.2403	7.938	0.05555	0.0361
⅜	16	0.3750	0.3344	0.2938	9.525	0.06250	0.0406
7/16	14	0.4375	0.3911	0.3447	11.113	0.07142	0.0464
½	13	0.5000	0.4500	0.4001	12.700	0.07692	0.0500
9/16	12	0.5625	0.5084	0.4542	14.288	0.08333	0.0541
⅝	11	0.6250	0.5660	0.5069	15.875	0.09090	0.0590
¾	10	0.7500	0.6850	0.6201	19.050	0.10000	0.0650
⅞	9	0.8750	0.8028	0.7307	22.225	0.11111	0.0722
1	8	1.0000	0.9188	0.8376	25.400	0.12500	0.0812
1⅛	7	1.1250	1.0322	0.9394	28.575	0.14285	0.0928
1¼	7	1.2500	1.1572	1.0644	31.750	0.14285	0.0928
1½	6	1.5000	1.3917	1.2835	38.100	0.16666	0.1083
1¾	5	1.7500	1.6201	1.4902	44.450	0.20000	0.1299
2	4½	2.0000	1.8557	1.7113	50.800	0.22222	0.1443
2¼	4½	2.2500	2.1057	1.9613	57.150	0.22222	0.1443
2½	4	2.5000	2.3376	2.1752	63.500	0.25000	0.1624
2¾	4	2.7500	2.5876	2.4252	69.850	0.25000	0.1624
3	4	3.0000	2.8376	2.6752	76.200	0.25000	0.1624

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TABLE 2. NATIONAL FINE THREAD SERIES

Numbered and Fractional Sizes	Number of Threads per Inch	Basic Diameters: Major Diam., Inches	Basic Diameters: Pitch Diam., Inches	Basic Diameters: Minor Diam., Inches	Metric Equivalent of Major Diam., Millimeters	Pitch, Inches	Depth of Thread, Inches
0	80	0.0600	0.0519	0.0438	1.524	0.01250	0.00812
1	72	0.0730	0.0640	0.0550	1.854	0.01388	0.00902
2	64	0.0860	0.0759	0.0657	2.184	0.01562	0.01014
3	56	0.0990	0.0874	0.0758	2.515	0.01785	0.01160
4	48	0.1120	0.0985	0.0849	2.845	0.02083	0.01353
5	44	0.1250	0.1102	0.0955	3.175	0.02272	0.01476
6	40	0.1380	0.1218	0.1055	3.506	0.02500	0.01624
8	36	0.1640	0.1460	0.1279	4.166	0.02777	0.01804
10	32	0.1900	0.1697	0.1494	4.826	0.03125	0.02030
12	28	0.2160	0.1928	0.1696	5.486	0.03571	0.02319
¼	28	0.2500	0.2268	0.2036	6.350	0.03571	0.02319
5/16	24	0.3125	0.2854	0.2584	7.938	0.04166	0.02706
⅜	24	0.3750	0.3479	0.3209	9.525	0.04166	0.02706
7/16	20	0.4375	0.4050	0.3725	11.113	0.05000	0.03248
½	20	0.5000	0.4675	0.4350	12.700	0.05000	0.03248
9/16	18	0.5625	0.5264	0.4903	14.288	0.05555	0.03608
⅝	18	0.6250	0.5889	0.5528	15.875	0.05555	0.03608
¾	16	0.7500	0.7094	0.6688	19.050	0.06250	0.04060
⅞	14	0.8750	0.8286	0.7822	22.225	0.07142	0.04640
1	14	1.0000	0.9536	0.9072	25.400	0.07142	0.04640
1⅛	12	1.1250	1.0709	1.0167	28.575	0.08333	0.05413
1¼	12	1.2500	1.1959	1.1417	31.750	0.08333	0.05413
1½	12	1.5000	1.4459	1.3917	38.100	0.08333	0.05413
1¾	12	1.7500	1.6959	1.6417	44.450	0.08333	0.05413
2	12	2.0000	1.9459	1.8917	50.800	0.08333	0.05413
2¼	12	2.2500	2.1959	2.1417	57.150	0.08333	0.05413
2½	12	2.5000	2.4459	2.3917	63.500	0.08333	0.05413
2¾	12	2.7500	2.6959	2.6417	69.850	0.08333	0.05413
3	10	3.0000	2.9350	2.8701	76.200	0.10000	0.06495

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National Fire Hose Coupling Threads

The National "fire hose" threads are intended for all couplings and hydrant connections for fire protection systems and for all other purposes where hose couplings and connections are required in sizes between 2½ and 4½ inches in diameter. The basic sizes and dimensions and the form of thread profile correspond to those recommended by the National Fire Protection Association and by the Bureau of Standards. The specifications are similar to those given in the table "Fire Hose Connections," page 1013, in MACHINERY'S HANDBOOK. Specifications for the special form of thread for fire hose couplings are given in the table referred to.

National Hose Coupling Threads

The National hose coupling thread is intended for all couplings and connections for sizes between ¾ inch and 2 inches in diameter. The form of thread profile is the same as the National (U. S. standard) form. The sizes and basic dimensions are specified in Table 3.

Manufacturing Specifications for National Screw Threads

The National coarse threads, fine threads, fire hose coupling threads, and hose coupling threads are to be produced in accordance with the following specifications covering the classification of screw thread fits and the tolerances. It is recommended that all specifications be so written that the qualities in the product desired shall be stated in definite terms of known measurable standards and correctly defined by the largest tolerance limits compatible with the satisfactory operation or performance of the articles or material for the purpose intended. To this end every factor involved in the acceptability of the manufactured product required should be comparable within specified limits with a known measurable standard. Every specification should be so concise that there can be no possible misunderstanding or dispute regarding the limiting lines of acceptance.

TABLE 3. NATIONAL HOSE COUPLING THREADS

Nominal Size, Inches	Thds. per Inch	Pitch, Inches	Depth of Thread, Inches	Major Diameter: Millimeters	Major Diameter: Inches	Pitch Diam., Inches	Minor Diam., Inches	Allowance, Inches
Basic Minimum Coupling Dimensions								
¾	11½	0.08696	0.0565	27.242	1.0725	1.0160	0.9595	0.01
1	11½	0.08696	0.0565	33.150	1.3051	1.2486	1.1922	0.01
1¼	11½	0.08696	0.0565	41.908	1.6499	1.5934	1.5369	0.01
1½	11½	0.08696	0.0565	47.976	1.8888	1.8323	1.7759	0.01
2	11½	0.08696	0.0565	60.015	2.3628	2.3063	2.2498	0.01
Basic Maximum Nipple Dimensions								
¾	11½	0.08696	0.0565	26.988	1.0625	1.0060	0.9495	0.01
1	11½	0.08696	0.0565	32.896	1.2951	1.2386	1.1822	0.01
1¼	11½	0.08696	0.0565	41.654	1.6399	1.5834	1.5269	0.01
1½	11½	0.08696	0.0565	47.722	1.8788	1.8223	1.7659	0.01
2	11½	0.08696	0.0565	59.761	2.3528	2.2963	2.2398	0.01

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The specifications previously referred to, covering classification and tolerances, are intended for the sole purpose of establishing the physical dimensions of screw thread products. While under tolerances various grades of workmanship are covered, it is not intended in any way to specify or limit the material or physical qualities required by the user. These specifications as to material and physical qualities must be established according to individual needs. Here again the importance of stating these requirements by concise and definite specifications is emphasized.

Classification of Screw Thread Fits

The National Screw Thread Commission established for general use, unless otherwise specified, four distinct classes of screw thread fits with certain subdivisions, for the purpose of insuring the interchangeable manufacture of screw thread parts throughout the country. The examples referred to in connection with each of the following classes of fits are for purposes of illustration only, as it was not the intention of the commission arbitrarily to place a general class or grade of work in a specific class of fit. Tables 4 to 15 give the tolerances and dimensions for each class of fit.

Loose Fit—This class includes screw threads of a rough commercial quality which must assemble readily, a certain amount of looseness or play not being objectionable, for example, stove bolts, carriage bolts, hose couplings, threads for artillery ammunition, and other similar threaded work.

Medium Fit — This class is subdivided into "regular" and "special" fits. The "regular" subdivision includes the great bulk of screw thread work of ordinary quality, such as finished and semi-finished bolts and nuts; machine screws; cap-screws; most of the fastening screws for instruments, small arms, and other ordnance; screws for sewing machines, typewriters, etc. The "special" subdivision includes the better grade of interchangeable screw thread work, such as high-grade automobile and aircraft bolts and nuts.

TABLE 4. ALLOWANCES AND TOLERANCES FOR LOOSE FIT

(Screws, Nuts and Gages)

No. of Thds. per Inch	Allowances, Inches	Extreme or Drawing Pitch Diam. Tolerances, Inches	Master Gage Tolerances: Diameter, Inches	Master Gage Tolerances: Lead,* Inches, Plus or Minus	Master Gage Tolerances: ½ Angle, Plus or Minus	Net Pitch Diameter Tolerances, Inches
80	0.0007	0.0024	0.0002	0.0002	0° 30′	0.0020
72	0.0007	0.0025	0.0002	0.0002	0° 30′	0.0021
64	0.0007	0.0026	0.0002	0.0002	0° 30′	0.0022
56	0.0008	0.0028	0.0002	0.0002	0° 30′	0.0024
48	0.0009	0.0031	0.0002	0.0002	0° 30′	0.0027
44	0.0009	0.0032	0.0002	0.0002	0° 30′	0.0028
40	0.0010	0.0034	0.0002	0.0002	0° 20′	0.0030
36	0.0011	0.0036	0.0002	0.0002	0° 20′	0.0032
32	0.0011	0.0038	0.0002	0.0002	0° 20′	0.0034
28	0.0012	0.0043	0.0003	0.0002	0° 15′	0.0037
24	0.0013	0.0046	0.0003	0.0002	0° 15′	0.0040
20	0.0015	0.0051	0.0003	0.0002	0° 15′	0.0045
18	0.0016	0.0057	0.0004	0.0003	0° 10′	0.0049
16	0.0018	0.0063	0.0004	0.0003	0° 10′	0.0055
14	0.0021	0.0070	0.0004	0.0003	0° 10′	0.0062
13	0.0022	0.0074	0.0004	0.0003	0° 10′	0.0066
12	0.0024	0.0079	0.0004	0.0003	0° 10′	0.0071
11	0.0026	0.0085	0.0004	0.0003	0° 10′	0.0077
10	0.0028	0.0092	0.0004	0.0004	0° 5′	0.0084
9	0.0031	0.0100	0.0004	0.0004	0° 5′	0.0092
8	0.0034	0.0111	0.0004	0.0004	0° 5′	0.0103
7	0.0039	0.0124	0.0004	0.0004	0° 5′	0.0116
6	0.0044	0.0145	0.0006	0.0005	0° 5′	0.0133
5	0.0052	0.0169	0.0006	0.0005	0° 5′	0.0157
4½	0.0057	0.0184	0.0006	0.0005	0° 5′	0.0172
4	0.0064	0.0204	0.0006	0.0005	0° 5′	0.0192

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*Allowable variation in lead between any two threads not farther apart than the length of engagement.

TABLE 5. ALLOWANCES AND TOLERANCES FOR MEDIUM FIT (REGULAR)

(Screws, Nuts and Gages)

No. of Thds. per Inch	Allowances, Inches	Extreme or Drawing Pitch Diam. Tolerances, Inches	Master Gage Tolerances: Diameter, Inches,	Master Gage Tolerances: Lead,* Inches, Plus or Minus	Master Gage Tolerances: ½ Angle, Plus or Minus	Net Pitch Diameter Tolerances, Inches
80	0.0000	0.0017	0.0002	0.0002	0° 30′	0.0013
72	0.0000	0.0018	0.0002	0.0002	0° 30′	0.0014
64	0.0000	0.0019	0.0002	0.0002	0° 30′	0.0015
56	0.0000	0.0020	0.0002	0.0002	0° 30′	0.0016
48	0.0000	0.0022	0.0002	0.0002	0° 30′	0.0018
44	0.0000	0.0023	0.0002	0.0002	0° 30′	0.0019
40	0.0000	0.0024	0.0002	0.0002	0° 20′	0.0020
36	0.0000	0.0025	0.0002	0.0002	0° 20′	0.0021
32	0.0000	0.0027	0.0002	0.0002	0° 20′	0.0023
28	0.0000	0.0031	0.0003	0.0002	0° 15′	0.0025
24	0.0000	0.0033	0.0003	0.0002	0° 15′	0.0027
20	0.0000	0.0036	0.0003	0.0002	0° 15′	0.0030
18	0.0000	0.0041	0.0004	0.0003	0° 10′	0.0033
16	0.0000	0.0045	0.0004	0.0003	0° 10′	0.0037
14	0.0000	0.0049	0.0004	0.0003	0° 10′	0.0041
13	0.0000	0.0052	0.0004	0.0003	0° 10′	0.0044
12	0.0000	0.0056	0.0004	0.0003	0° 10′	0.0048
11	0.0000	0.0059	0.0004	0.0003	0° 10′	0.0051
10	0.0000	0.0064	0.0004	0.0004	0° 5′	0.0056
9	0.0000	0.0070	0.0004	0.0004	0° 5′	0.0062
8	0.0000	0.0076	0.0004	0.0004	0° 5′	0.0068
7	0.0000	0.0085	0.0004	0.0004	0° 5′	0.0077
6	0.0000	0.0101	0.0006	0.0005	0° 5′	0.0089
5	0.0000	0.0116	0.0006	0.0005	0° 5′	0.0104
4½	0.0000	0.0127	0.0006	0.0005	0° 5′	0.0115
4	0.0000	0.0140	0.0006	0.0005	0° 5′	0.0128

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*Allowable variation in lead between any two threads not farther apart than the length of engagement.

Close Fit—This class includes screw thread work requiring a fine snug fit, which is somewhat closer than the "special" medium fit. Selective assembly of parts may be required for screw threads of the "close fit" class.

Wrench Fit—This class applies to threaded parts of ¼-inch diameter or larger, which are to be set or assembled with a wrench. As the material in this case is an important factor in determining the fit between the threaded members, there are two subdivisions for this class of fit, which differ mainly in the amount of allowance (interference) values for the different pitches. The first subdivision includes screw threads used in light sections with moderate stresses, such as aircraft and automobile engine work. The second subdivision includes screw threads used in heavy sections and for higher stresses, as for example in steam engine and heavy hydraulic work. On account of the lack of data, tolerances and allowances are not specified for wrench fits.

General Specifications

The following general specifications apply to the different classes of screw thread fits referred to:

Basic Diameter—The minimum threaded hole or nut corresponds to the basic size; that is, the pitch diameter of the minimum nut is basic for all classes of fit. This condition permits the use of taps which when new are over size and which are discarded when the hole cut is the basic size. In order to secure the desired fit, the screw size is varied. Thus, the maximum screw corresponds to the basic size for the "medium fit" class, is slightly above basic size for the "close fit" class, considerably above the basic size for the "wrench fit" class, and below the basic size for the "loose fit" class.

Length of Engagement—The maximum length of engagement for screw threads manufactured in accordance with any of the classes of fit specified shall not exceed the amount

TABLE 6. LOOSE FIT—NATIONAL COARSE THREAD SERIES

Numbered and Fractional Sizes	No. of Threads per Inch	Screw Sizes: Major Diam. Max. Inches	Screw Sizes: Major Diam. Min. Inches	Screw Sizes: Pitch Diam. Max. Inches	Screw Sizes: Pitch Diam. Min. Inches	Screw Sizes: Minor Diam. Max.* Inches	Screw Sizes: Minor Diam. Min. Inches	Nut Sizes: Minor Diam. Min. Inches	Nut Sizes: Minor Diam. Max. Inches	Nut Sizes: Pitch Diam. Min. Inches	Nut Sizes: Pitch Diam. Max. Inches	Nut Sizes: Major Diam. Min.* Inches	Nut Sizes: Major Diam. Max. Inches	Basic Major Diam., Inches	Numbered and Fractional Sizes
1	64	0.0723	0.0671	0.0622	0.0596	0.0531	0.0494	0.0561	0.0578	0.0629	0.0655	0.0741	0.0779	0.0730	1
2	56	0.0852	0.0796	0.0736	0.0708	0.0633	0.0592	0.0667	0.0686	0.0744	0.0772	0.0873	0.0914	0.0860	2
3	48	0.0981	0.0881	0.0846	0.0815	0.0725	0.0679	0.0764	0.0787	0.0855	0.0886	0.1005	0.1051	0.0990	3
4	40	0.1110	0.1042	0.0948	0.0914	0.0803	0.c751	0.0849	0.0876	0.0958	0.0992	0.1138	0.1190	0.1120	4
5	40	0.1240	0.1172	0.1078	0.1044	0.0933	0.0881	0.0979	0.1006	0.1088	0.1122	0.1268	0.1320	0.1250	5
6	32	0.1369	0.1293	0.1166	0.1128	0.0986	0.0925	0.1042	0.1076	0.1177	0.1215	0.1403	0.1463	0.1380	6
8	32	0.1629	0.1553	0.1426	0.1388	0.1246	0.1186	0.1302	0.1336	0.1437	0.1475	0.1663	0.1723	0.1640	8
10	24	0.1887	0.1795	0.1616	0.1570	0.1376	0.1300	0.1449	0.1494	0.1629	0.1675	0.1930	0.2006	0.1900	10
12	24	0.2147	0.2055	0.1876	0.1830	0.1636	0.1560	0.1709	0.1754	0.1889	0.1935	0.2190	0.2266	0.2160	12
¼	20	0.2485	0.2383	0.2160	0.2109	0.1872	0.1784	0.1959	0.2013	0.2175	0.2226	0.2536	0.2623	0.2500	¼
5/16	18	0.3109	0.2995	0.2748	0.2691	0.2427	0.2330	0.2524	0.2584	0.2764	0.2821	0.3165	0.3262	0.3125	5/16
⅜	16	0.3732	0.3606	0.3326	0.3263	0.2965	0.2857	0.3073	0.3141	0.3344	0.3407	0.3795	0.3903	0.3750	⅜
7/16	14	0.4354	0.4214	0.3890	0.3820	0.3478	0.3356	0.3602	0.3679	0.3911	0.3981	0.4427	0.4548	0.4375	7/16
½	13	0.4978	0.4830	0.4478	0.4404	0.4034	0.3905	0.4167	0.4251	0.4500	0.4574	0.5056	0.5185	0.5000	½
9/16	12	0.5601	0.5443	0.4960	0.4881	0.4579	0.4339	0.4723	0.4813	0.5084	0.5183	0.5685	0.5824	0.5625	9/16
⅝	11	0.6224	0.6054	0.5634	0.5549	0.5109	0.4998	0.5266	0.5364	0.5660	0.5745	0.6316	0.6466	0.6250	⅝
¾	10	0.7472	0.7288	0.6822	0.6730	0.6245	0.6125	0.6417	0.6526	0.6850	0.6942	0.7572	0.7736	0.7500	¾
⅞	9	0.8719	0.8519	0.7997	0.7897	0.7356	0.7225	0.7547	0.7667	0.8028	0.8128	0.8830	0.9010	0.8750	⅞
1	8	0.9966	0.9744	0.9154	0.9043	0.8432	0.8287	0.8647	0.8782	0.9188	0.9299	1.0090	1.0291	1.0000	1
1⅛	7	1.1211	1.0963	1.0283	1.0159	0.9458	0.9295	0.9704	0.9858	1.0322	1.0446	1.1353	1.1580	1.1250	1⅛
1¼	7	1.2461	1.2213	1.1533	1.1409	1.0708	1.0545	1.0954	1.1108	1.1572	1.1696	1.2603	1.2830	1.2500	1¼
1½	6	1.4956	1.4666	1.3873	1.3728	1.2911	1.2712	1.3196	1.3376	1.3917	1.4062	1.5120	1.5386	1.5000	1½
1¾	5	1.7448	1.7110	1.6149	1.5980	1.4994	1.4773	1.5335	1.5551	1.6201	1.6370	1.7644	1.7958	1.7500	1¾
2	4½	1.9943	1.9575	1.8500	1.8316	1.7217	1.6976	1.7594	1.7835	1.8557	1.8741	2.0160	2.0505	2.0000	2
2¼	4½	2.2443	2.2075	2.1000	2.0816	1.9717	1.9476	2.0094	2.0335	2.1057	2.1241	2.2660	2.3005	2.2500	2¼
2½	4	2.4936	2.4528	2.3312	2.3108	2.1869	2.1601	2.2294	2.2564	2.3376	2.3580	2.5180	2.5565	2.5000	2½
2¾	4	2.7436	2.7028	2.5812	2.5608	2.4369	2.4101	2.4794	2.5064	2.5876	2.6080	2.7680	2.8065	2.7500	2¾
3	4	2.9936	2.9528	2.8312	2.8108	2.6869	2.6601	2.7294	2.7564	2.8376	2.8580	3.0180	3.0565	3.0000	3

* Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root (see accompanying diagram). The dimensions given in the tables of screw and nut sizes are the dimensions of the work and not the gages.

determined by the following formula, in which L = length of engagement and D = basic major diameter of thread:

$$L = 1.5\ D$$

Scope of Classification—The specifications established for the various classes of fit are applicable to the National coarse threads, fine threads, hose threads, and to any special thread required in manufacture which is not intentionally tapered.

Tolerances and Diameters for Loose Fits

The "loose fit" class of screw threads is intended to cover the manufacture of strictly interchangeable threaded parts which are produced in two or more manufacturing plants, and this class applies to work of such a nature that rapid assembly is necessary, and a certain amount of looseness or play is not objectionable.

Minimum Nut Basic Size—The pitch diameter of the minimum nut of a given diameter and pitch corresponds to the basic pitch diameter. For example, the minimum pitch diameter of a nut for a nominal screw thread size of ¼ inch is 0.2175 inch as given in the right-hand half of Table 6; this corresponds to the basic pitch diameter for the National coarse thread series as given in Table 1. The accompanying diagram illustrates the tolerances, allowances, and clearances for a 1-inch screw thread (eight threads per inch) of the "loose fit" class.

Maximum Screw below Basic Size—The major and pitch diameters of a maximum screw of given pitch and diameter are below the basic dimensions specified in Table 1 by the amount of allowance given in Table 4. For example, the maximum pitch diameter of a ¼-inch screw thread (see Table 6) is 0.2160. The basic pitch diameter (see Table 1) is 0.2175. Hence, the difference equals 0.2175 — 0.2160 = 0.0015, which equals the allowance given in Table 4 for twenty threads per inch. The maximum minor diameter of the screw is above the basic minor diameter.

Direction of Tolerances—The tolerance on a nut will be plus, and is to be applied from the basic size to above the basic size. The tolerance on the screw will be minus, and

TABLE 7. LOOSE FIT—NATIONAL FINE THREAD SERIES

Numbered and Fractional Sizes	No. of Threads per Inch	Screw Sizes						Nut Sizes						Basic Major Diam., Inches	Numbered and Fractional Sizes
		Major Diam.		Pitch Diam.		Minor Diam.		Minor Diam.		Pitch Diam.		Major Diam.			
		Max. Inches	Min. Inches	Max. Inches	Min. Inches	Max.* Inches	Min. Inches	Min. Inches	Max. Inches	Min. Inches	Max. Inches	Min.* Inches	Max. Inches		
0	80	0.0593	0.0545	0.0512	0.0488	0.0440	0.0407	0.0465	0.0478	0.0519	0.0543	0.0609	0.0642	0.0600	0
1	72	0.0723	0.0673	0.0633	0.0608	0.0553	0.0518	0.0580	0.0595	0.0640	0.0665	0.0740	0.0775	0.0730	1
2	64	0.0853	0.0801	0.0752	0.0726	0.0661	0.0624	0.0691	0.0708	0.0759	0.0785	0.0871	0.0909	0.0860	2
3	56	0.0982	0.0926	0.0866	0.0838	0.0763	0.0722	0.0797	0.0816	0.0874	0.0902	0.1003	0.1044	0.0990	3
4	48	0.1111	0.1049	0.0976	0.0945	0.0855	0.0809	0.0894	0.0917	0.0985	0.1016	0.1135	0.1181	0.1120	4
5	44	0.1241	0.1177	0.1093	0.1061	0.0962	0.0914	0.1004	0.1029	0.1102	0.1134	0.1266	0.1315	0.1250	5
6	40	0.1370	0.1302	0.1208	0.1174	0.1063	0.1011	0.1109	0.1136	0.1218	0.1252	0.1398	0.1450	0.1380	6
8	36	0.1629	0.1557	0.1449	0.1413	0.1288	0.1232	0.1339	0.1369	0.1460	0.1496	0.1660	0.1716	0.1640	8
10	32	0.1899	0.1823	0.1686	0.1648	0.1506	0.1445	0.1562	0.1596	0.1697	0.1735	0.1923	0.1983	0.1900	10
12	28	0.2148	0.2062	0.1916	0.1873	0.1710	0.1541	0.1773	0.1812	0.1928	0.1971	0.2186	0.2255	0.2160	12
¼	28	0.2488	0.2402	0.2256	0.2213	0.2050	0.1981	0.2113	0.2152	0.2258	0.2311	0.2526	0.2595	0.2500	¼
5/16	24	0.3112	0.3020	0.2841	0.2795	0.2601	0.2525	0.2674	0.2719	0.2854	0.2900	0.3155	0.3231	0.3125	5/16
⅜	24	0.3737	0.3645	0.3466	0.3420	0.3225	0.3150	0.3299	0.3344	0.3479	0.3425	0.3780	0.3856	0.3750	⅜
7/16	20	0.4350	0.4258	0.4035	0.3984	0.3747	0.3659	0.3834	0.3888	0.4050	0.4101	0.4411	0.4498	0.4375	7/16
½	20	0.4985	0.4883	0.4660	0.4609	0.4372	0.4284	0.4459	0.4513	0.4675	0.4726	0.5036	0.5123	0.5000	½
9/16	18	0.5609	0.5495	0.5248	0.5191	0.4927	0.4830	0.5024	0.5084	0.5264	0.5321	0.5665	0.5762	0.5625	9/16
⅝	18	0.6234	0.6120	0.5873	0.5816	0.5552	0.5455	0.5649	0.5709	0.5889	0.5946	0.6290	0.6387	0.6250	⅝
¾	16	0.7482	0.7356	0.7076	0.7013	0.6715	0.6607	0.6823	0.6891	0.7094	0.7157	0.7545	0.7653	0.7500	¾
⅞	14	0.8629	0.8489	0.8255	0.8195	0.7853	0.7731	0.7977	0.8054	0.8286	0.8356	0.8802	0.8923	0.8750	⅞
1	14	0.9979	0.9839	0.9515	0.9445	0.9103	0.8981	0.9227	0.9304	0.9536	0.9606	1.0052	1.0173	1.0000	1
1⅛	12	1.1226	1.1068	1.0685	1.0606	1.0204	1.0064	1.0348	1.0438	1.0709	1.0788	1.1310	1.1449	1.1250	1⅛
1¼	12	1.2476	1.2318	1.1935	1.1856	1.1454	1.1314	1.1598	1.1688	1.1959	1.2038	1.2560	1.2699	1.2500	1¼
1½	12	1.4976	1.3818	1.4435	1.4356	1.3954	1.3814	1.4098	1.4188	1.4459	1.4538	1.5060	1.5199	1.5000	1½
1¾	12	1.7476	1.7318	1.6935	1.6856	1.6454	1.6314	1.6598	1.6688	1.6959	1.7038	1.7560	1.7699	1.7500	1¾
2	12	1.9976	1.9818	1.9435	1.9356	1.8954	1.8814	1.9098	1.9188	1.9459	1.9538	2.0060	2.0199	2.0000	2
2¼	12	2.2476	2.2318	2.1935	2.1856	2.1454	2.1314	2.1598	2.1688	2.1959	2.2038	2.2560	2.2699	2.2500	2¼
2½	12	2.4976	2.4818	2.4435	2.4356	2.3954	2.3814	2.4098	2.4188	2.4459	2.4538	2.5060	2.5199	2.5000	2½
2¾	12	2.7476	2.7318	2.6935	2.6856	2.6454	2.6314	2.6598	2.6688	2.6959	2.7038	2.7560	2.7699	2.7500	2¾
3	10	2.9972	2.9788	2.9332	2.9240	2.8745	2.8581	2.8917	2.9026	2.9350	2.9442	3.0072	3.0236	3.0000	3

* Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root.

TABLE 8. MEDIUM FIT (REGULAR)—NATIONAL COARSE THREAD SERIES

Numbered and Fractional Sizes	No. of Threads per Inch	Screw Sizes						Nut Sizes						Basic Major Diam., Inches	Numbered and Fractional Sizes
		Major Diam.		Pitch Diam.		Minor Diam.		Minor Diam.		Pitch Diam.		Major Diam.			
		Max. Inches	Min. Inches	Max. Inches	Min. Inches	Max.* Inches	Min. Inches	Min. Inches	Max. Inches	Min. Inches	Max. Inches	Min.* Inches	Max. Inches		
1	64	0.0730	0.0692	0.0629	0.0610	0.0538	0.0508	0.0561	0.0578	0.0629	0.0648	0.0741	0.0772	0.0730	1
2	56	0.0860	0.0820	0.0744	0.0724	0.0641	0.0608	0.0667	0.0686	0.0744	0.0764	0.0873	0.0906	0.0860	2
3	48	0.0990	0.0946	0.0855	0.0833	0.0734	0.0697	0.0764	0.0787	0.0855	0.0877	0.1005	0.1042	0.0990	3
4	40	0.1120	0.1072	0.0958	0.0934	0.0813	0.0771	0.0849	0.0876	0.0958	0.0982	0.1138	0.1180	0.1120	4
5	40	0.1250	0.1202	0.1088	0.1064	0.0943	0.0901	0.0979	0.1006	0.1088	0.1112	0.1268	0.1310	0.1250	5
6	32	0.1380	0.1326	0.1177	0.1150	0.0997	0.0947	0.1042	0.1076	0.1177	0.1204	0.1403	0.1452	0.1380	6
8	32	0.1640	0.1586	0.1437	0.1410	0.1257	0.1207	0.1302	0.1336	0.1437	0.1464	0.1663	0.1712	0.1640	8
10	24	0.1900	0.1834	0.1629	0.1596	0.1389	0.1326	0.1449	0.1494	0.1629	0.1662	0.1930	0.1992	0.1900	10
12	24	0.2160	0.2094	0.1889	0.1856	0.1649	0.1586	0.1709	0.1754	0.1889	0.1922	0.2190	0.2253	0.2160	12
¼	20	0.2500	0.2428	0.2175	0.2139	0.1887	0.1814	0.1959	0.2013	0.2175	0.2211	0.2536	0.2608	0.2500	¼
5/16	18	0.3125	0.3043	0.2764	0.2723	0.2443	0.2362	0.2524	0.2584	0.2764	0.2805	0.3165	0.3246	0.3125	5/16
⅜	16	0.3750	0.3660	0.3344	0.3299	0.2983	0.2893	0.3073	0.3141	0.3344	0.3389	0.3795	0.3895	0.3750	⅜
7/16	14	0.4375	0.4277	0.3911	0.3862	0.3499	0.3398	0.3602	0.3679	0.3911	0.3960	0.4427	0.4527	0.4375	7/16
½	13	0.5000	0.4896	0.4500	0.4448	0.4056	0.3949	0.4167	0.4251	0.4500	0.4552	0.5056	0.5163	0.5000	½
9/16	12	0.5625	0.5513	0.5084	0.5028	0.4603	0.4486	0.4723	0.4813	0.5084	0.5140	0.5685	0.5800	0.5625	9/16
⅝	11	0.6250	0.6132	0.5660	0.5601	0.5135	0.5010	0.5266	0.5364	0.5660	0.5719	0.6316	0.6440	0.6250	⅝
¾	10	0.7500	0.7372	0.6850	0.6786	0.6273	0.6137	0.6417	0.6526	0.6850	0.6914	0.7572	0.7708	0.7500	¾
⅞	9	0.8750	0.8610	0.8028	0.7958	0.7387	0.7237	0.7547	0.7667	0.8028	0.8098	0.8830	0.8980	0.8750	⅞
1	8	1.0000	0.9848	0.9188	0.9112	0.8466	0.8300	0.8647	0.8782	0.9188	0.9264	1.0090	1.0256	1.0000	1
1⅛	7	1.1250	1.1080	1.0322	1.0237	0.9497	0.9309	0.9704	0.9858	1.0322	1.0407	1.1353	1.1541	1.1250	1⅛
1¼	7	1.2500	1.2330	1.1572	1.1487	1.0747	1.0559	1.0954	1.1108	1.1572	1.1657	1.2603	1.2791	1.2500	1¼
1½	6	1.5000	1.4798	1.3917	1.3816	1.2955	1.2734	1.3196	1.3376	1.3917	1.4018	1.5120	1.5342	1.5000	1½
1¾	5	1.7500	1.7268	1.6201	1.6085	1.5046	1.4786	1.5335	1.5551	1.6201	1.6317	1.7644	1.7905	1.7500	1¾
2	4½	2.0000	1.9746	1.8557	1.8430	1.7274	1.6986	1.7594	1.7835	1.8557	1.8684	2.0160	2.0448	2.0000	2
2¼	4½	2.2500	2.2246	2.1057	2.0930	1.9774	1.9386	2.0094	2.0335	2.1057	2.1184	2.2660	2.2948	2.2500	2¼
2½	4	2.5000	2.4720	2.3376	2.3236	2.1933	2.1612	2.2294	2.2564	2.3376	2.3516	2.5180	2.5501	2.5000	2½
2¾	4	2.7500	2.7220	2.5876	2.5736	2.4433	2.4112	2.4794	2.5064	2.5876	2.6016	2.7680	2.8001	2.7500	2¾
3	4	3.0000	2.9720	2.8376	2.8276	2.6933	2.6612	2.7294	2.7564	2.8376	2.8516	3.0180	3.0501	3.0000	3

* Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root.

is applied from the maximum screw dimension to below the maximum screw dimension.

Allowance and Tolerance Values—The allowance provided between the size of the minimum nut, which is basic, and the size of the maximum screw for a screw thread of given pitch will be as specified in Table 4. The tolerance on a screw or nut of a given pitch will also be as there specified.

Tolerances and Diameters for Medium Fits

As previously explained, screw threads of the "medium fit" class are subdivided into "regular" and "special" fits. The "regular" fits are intended to apply to interchangeable manufacture where the threaded members are to be assembled nearly or entirely with the fingers and where a moderate amount of play between the assembled threaded members is not objectionable.

Minimum Nut and Maximum Screw Basic Sizes—The pitch diameter of the minimum nut and also the major diameter and pitch diameter of the maximum screw of a given pitch and diameter correspond to the basic dimensions. The maximum minor diameter of the screw is above the basic minor diameter.

Direction of Tolerance on Nut and Screw—The tolerance on the nut will be plus and is to be applied from the basic size to above the basic size. The tolerance on the screw will be minus and is applied from the basic size to below the basic size.

Allowance and Tolerance—The allowance between the size of the maximum screw and minimum nut will be zero for all pitches and all diameters. The tolerance for a screw or nut of a given pitch will be as specified in Table 5. The "special" fits of the medium class apply particularly to high grades of automobile screw thread work. This "special" subdivision of the "medium fit" class is the same as the "regular" subdivision except that the tolerances are smaller as shown by Table 12.

TABLE 9. MEDIUM FIT (REGULAR)—NATIONAL FINE THREAD SERIES

Numbered and Fractional Sizes	No. of Threads per Inch	Screw Sizes						Nut Sizes						Basic Major Diam., Inches	Numbered and Fractional Sizes
		Major. Diam.		Pitch Diam.		Minor Diam.		Minor Diam.		Pitch Diam.		Major Diam.			
		Max. Inches	Min. Inches	Max. Inches	Min. Inches	Max.* Inches	Min. Inches	Min. Inches	Max. Inches	Min. Inches	Max. Inches	Min.* Inches	Max. Inches		
0	80	0.0600	0.0566	0.0519	0.0502	0.0447	0.0421	0.0465	0.0478	0.0519	0.0536	0.0609	0.0635	0.0600	0
1	72	0.0730	0.0694	0.0640	0.0622	0.0560	0.0532	0.0580	0.0595	0.0640	0.0658	0.0740	0.0768	0.0730	1
2	64	0.0860	0.0822	0.0759	0.0740	0.0668	0.0638	0.0691	0.0708	0.0759	0.0778	0.0871	0.0902	0.0860	2
3	56	0.0990	0.0950	0.0874	0.0854	0.0771	0.0738	0.0797	0.0816	0.0874	0.0894	0.1003	0.1036	0.0990	3
4	48	0.1120	0.1076	0.0985	0.0963	0.0864	0.0827	0.0894	0.0917	0.0985	0.1007	0.1135	0.1172	0.1120	4
5	44	0.1250	0.1204	0.1102	0.1079	0.0971	0.0932	0.1004	0.1029	0.1102	0.1125	0.1266	0.1306	0.1250	5
6	40	0.1380	0.1332	0.1218	0.1194	0.1073	0.1031	0.1109	0.1136	0.1218	0.1242	0.1398	0.1440	0.1380	6
8	36	0.1640	0.1590	0.1460	0.1435	0.1299	0.1254	0.1339	0.1369	0.1460	0.1485	0.1660	0.1705	0.1640	8
10	32	0.1900	0.1846	0.1697	0.1670	0.1517	0.1467	0.1562	0.1596	0.1697	0.1724	0.1923	0.1972	0.1900	10
12	28	0.2160	0.2098	0.1928	0.1897	0.1722	0.1665	0.1773	0.1812	0.1928	0.1959	0.2186	0.2243	0.2160	12
¼	28	0.2500	0.2438	0.2268	0.2237	0.2062	0.2005	0.2113	0.2152	0.2268	0.2299	0.2526	0.2583	0.2500	¼
5/16	24	0.3125	0.3059	0.2854	0.2821	0.2614	0.2551	0.2674	0.2719	0.2854	0.2887	0.3155	0.3218	0.3125	5/16
⅜	24	0.3750	0.3684	0.3479	0.3446	0.3239	0.3176	0.3299	0.3344	0.3479	0.3512	0.3780	0.3843	0.3750	⅜
7/16	20	0.4375	0.4303	0.4050	0.4014	0.3762	0.3689	0.3834	0.3888	0.4050	0.4086	0.4411	0.4483	0.4375	7/16
½	20	0.5000	0.4928	0.4675	0.4639	0.4387	0.4314	0.4459	0.4513	0.4675	0.4711	0.5036	0.5108	0.5000	½
9/16	18	0.5625	0.5543	0.5264	0.5223	0.4943	0.4862	0.5024	0.5084	0.5264	0.5305	0.5665	0.5746	0.5625	9/16
⅝	18	0.6250	0.6168	0.5889	0.5848	0.5568	0.5487	0.5649	0.5709	0.5889	0.5930	0.6290	0.6371	0.6250	⅝
¾	16	0.7500	0.7410	0.7094	0.7049	0.6733	0.6643	0.6823	0.6891	0.7094	0.7139	0.7545	0.7635	0.7500	¾
⅞	14	0.8750	0.8652	0.8286	0.8237	0.7874	0.7773	0.7977	0.8054	0.8286	0.8335	0.8802	0.8902	0.8750	⅞
1	14	1.0000	0.9902	0.9536	0.9487	0.9124	0.9023	0.9227	0.9304	0.9536	0.9585	1.0052	1.0152	1.0000	1
1⅛	12	1.1250	1.1138	1.0709	1.0653	1.0228	1.0111	1.0348	1.0438	1.0709	1.0765	1.1310	1.1426	1.1250	1⅛
1¼	12	1.2500	1.2388	1.1959	1.1903	1.1478	1.1361	1.1598	1.1688	1.1959	1.2015	1.2560	1.2676	1.2500	1¼
1½	12	1.5000	1.4888	1.4459	1.4403	1.3978	1.3861	1.4098	1.4188	1.4459	1.4515	1.5060	1.5176	1.5000	1½
1¾	12	1.7500	1.7388	1.6959	1.6903	1.6478	1.6361	1.6598	1.6688	1.6959	1.7015	1.7560	1.7676	1.7500	1¾
2	12	2.0000	1.9888	1.9459	1.9403	1.8978	1.8861	1.9098	1.9188	1.9459	1.9515	2.0060	2.0176	2.0000	2
2¼	12	2.2500	2.2388	2.1959	2.1903	2.1478	2.1361	2.1598	2.1688	2.1959	2.2015	2.2560	2.2676	2.2500	2¼
2½	12	2.5000	2.4888	2.4459	2.4403	2.3978	2.3861	2.4098	2.4188	2.4459	2.4515	2.5060	2.5176	2.5000	2½
2¾	12	2.7500	2.7388	2.6959	2.6903	2.6478	2.6361	2.6598	2.6688	2.6959	2.7015	2.7560	2.7676	2.7500	2¾
3	10	3.0000	2.9872	2.9350	2.9286	2.8773	2.8637	2.8917	2.9026	2.9350	2.9414	3.0072	3.0208	3.0000	3

* Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root.

TABLE 10. MEDIUM FIT (SPECIAL)—NATIONAL COARSE THREAD SERIES

Numbered and Fractional Sizes	No. of Threads per Inch	Screw Sizes						Nut Sizes						Basic Major Diam., Inches	Numbered and Fractional Sizes
		Major Diam.		Pitch Diam.		Minor Diam.		Minor Diam.		Pitch Diam.		Major Diam.			
		Max. Inches	Min. Inches	Max. Inches	Min. Inches	Max.* Inches	Min. Inches	Min. Inches	Max. Inches	Min. Inches	Max. Inches	Min.* Inches	Max. Inches		
1	64	0.0730	0.0702	0.0629	0.0615	0.0538	0.0513	0.0561	0.0578	0.0629	0.0643	0.0741	0.0767	0.0730	1
2	56	0.0860	0.0830	0.0744	0.0729	0.0641	0.0613	0.0667	0.0686	0.0744	0.0759	0.0873	0.0901	0.0860	2
3	48	0.0990	0.0958	0.0855	0.0839	0.0734	0.0703	0.0764	0.0787	0.0855	0.0871	0.1005	0.1036	0.0990	3
4	40	0.1120	0.1086	0.0958	0.0941	0.0813	0.0778	0.0849	0.0876	0.0958	0.0975	0.1138	0.1173	0.1120	4
5	40	0.1250	0.1216	0.1088	0.1071	0.0943	0.0908	0.0979	0.1006	0.1088	0.1105	0.1268	0.1303	0.1250	5
6	32	0.1380	0.1342	0.1177	0.1158	0.0997	0.0955	0.1042	0.1076	0.1177	0.1196	0.1403	0.1444	0.1380	6
8	32	0.1640	0.1602	0.1437	0.1418	0.1257	0.1215	0.1302	0.1336	0.1437	0.1456	0.1663	0.1704	0.1640	8
10	24	0.1900	0.1852	0.1629	0.1605	0.1389	0.1335	0.1449	0.1494	0.1629	0.1653	0.1930	0.1984	0.1900	10
12	24	0.2160	0.2112	0.1889	0.1865	0.1649	0.1595	0.1709	0.1754	0.1889	0.1913	0.2190	0.2244	0.2160	12
¼	20	0.2500	0.2448	0.2175	0.2149	0.1887	0.1824	0.1959	0.2013	0.2175	0.2201	0.2536	0.2598	0.2500	¼
5/16	18	0.3125	0.3065	0.2764	0.2734	0.2443	0.2373	0.2524	0.2584	0.2764	0.2794	0.3165	0.3235	0.3125	5/16
⅜	16	0.3750	0.3686	0.3344	0.3312	0.2983	0.2906	0.3073	0.3141	0.3344	0.3376	0.3795	0.3862	0.3750	⅜
7/16	14	0.4375	0.4303	0.3911	0.3875	0.3499	0.3411	0.3602	0.3679	0.3911	0.3947	0.4427	0.4514	0.4375	7/16
½	13	0.5000	0.4926	0.4500	0.4463	0.4056	0.3964	0.4167	0.4251	0.4500	0.4537	0.5056	0.5148	0.5000	½
9/16	12	0.5625	0.5545	0.5084	0.5044	0.4603	0.4502	0.4723	0.4813	0.5084	0.5124	0.5685	0.5785	0.5625	9/16
⅝	11	0.6250	0.6166	0.5660	0.5618	0.5135	0.5027	0.5266	0.5364	0.5660	0.5702	0.6316	0.6423	0.6250	⅝
¾	10	0.7500	0.7410	0.6850	0.6805	0.6273	0.6156	0.6417	0.6526	0.6850	0.6895	0.7572	0.7689	0.7500	¾
⅞	9	0.8750	0.8652	0.8028	0.7979	0.7387	0.7258	0.7547	0.7667	0.8028	0.8077	0.8830	0.8959	0.8750	⅞
1	8	1.0000	0.9892	0.9188	0.9134	0.8466	0.8322	0.8647	0.8782	0.9188	0.9242	1.0090	1.0234	1.0000	1
1⅛	7	1.1250	1.1132	1.0322	1.0263	0.9497	0.9335	0.9704	0.9858	1.0322	1.0381	1.1353	1.1515	1.1250	1⅛
1¼	7	1.2500	1.2382	1.1572	1.1513	1.0747	1.0585	1.0954	1.1108	1.1572	1.1631	1.2603	1.2765	1.2500	1¼
1½	6	1.5000	1.4858	1.3917	1.3846	1.2955	1.2764	1.3196	1.3376	1.3917	1.3988	1.5120	1.5312	1.5000	1½
1¾	5	1.7500	1.7336	1.6201	1.6119	1.5046	1.4820	1.5335	1.5551	1.6201	1.6283	1.7644	1.7871	1.7500	1¾
2	4½	2.0000	1.9822	1.8557	1.8468	1.7274	1.7024	1.7594	1.7835	1.8557	1.8646	2.0160	2.0410	2.0000	2
2¼	4½	2.2500	2.2322	2.1057	2.0968	1.9774	1.9524	2.0094	2.0335	2.1057	2.1146	2.2660	2.2910	2.2500	2¼
2½	4	2.5000	2.4806	2.3376	2.3279	2.1933	2.1655	2.2294	2.2564	2.3376	2.3473	2.5180	2.5458	2.5000	2½
2¾	4	2.7500	2.7306	2.5876	2.5779	2.4433	2.4155	2.4794	2.5064	2.5876	2.6973	2.7680	2.7958	2.7500	2¾
3	4	3.0000	2.9806	2.8376	2.8279	2.6933	2.6655	2.7294	2.7564	2.8376	2.8473	3.0180	3.0458	3.0000	3

* Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root.

TABLE 11. MEDIUM FIT (SPECIAL)—NATIONAL FINE THREAD SERIES

Numbered and Fractional Sizes	No. of Threads per Inch	Screw Sizes						Nut Sizes						Basic Major Diam., Inches	Numbered and Fractional Sizes
		Major Diam.		Pitch Diam.		Minor Diam.		Minor Diam.		Pitch Diam.		Major Diam.			
		Max. Inches	Min. Inches	Max. Inches	Min. Inches	Max.* Inches	Min. Inches	Min. Inches	Max. Inches	Min. Inches	Max. Inches	Min.* Inches	Max. Inches		
0	80	0.0600	0.0574	0.0519	0.0506	0.0447	0.0425	0.0465	0.0478	0.0519	0.0532	0.0609	0.0631	0.0600	0
1	72	0.0730	0.0704	0.0640	0.0627	0.0560	0.0537	0.0580	0.0595	0.0640	0.0653	0.0740	0.0763	0.0730	1
2	64	0.0860	0.0832	0.0759	0.0745	0.0668	0.0643	0.0691	0.0708	0.0759	0.0773	0.0871	0.0897	0.0860	2
3	56	0.0990	0.0960	0.0874	0.0859	0.0771	0.0743	0.0797	0.0816	0.0874	0.0889	0.1003	0.1031	0.0990	3
4	48	0.1120	0.1088	0.0985	0.0969	0.0864	0.0833	0.0894	0.0917	0.0985	0.1001	0.1135	0.1166	0.1120	4
5	44	0.1250	0.1218	0.1102	0.1086	0.0971	0.0939	0.1004	0.1029	0.1102	0.1118	0.1266	0.1299	0.1250	5
6	40	0.1380	0.1346	0.1218	0.1201	0.1073	0.1038	0.1109	0.1136	0.1218	0.1235	0.1398	0.1433	0.1380	6
8	36	0.1640	0.1604	0.1460	0.1442	0.1299	0.1261	0.1339	0.1369	0.1460	0.1478	0.1660	0.1698	0.1640	8
10	32	0.1900	0.1862	0.1697	0.1678	0.1517	0.1475	0.1562	0.1596	0.1697	0.1716	0.1923	0.1964	0.1900	10
12	28	0.2160	0.2116	0.1928	0.1906	0.1722	0.1674	0.1773	0.1812	0.1928	0.1950	0.2186	0.2234	0.2160	12
1/4	28	0.2500	0.2456	0.2268	0.2246	0.2062	0.2014	0.2113	0.2152	0.2268	0.2290	0.2526	0.2574	0.2500	1/4
5/16	24	0.3125	0.3077	0.2854	0.2830	0.2614	0.2560	0.2674	0.2719	0.2854	0.2878	0.3155	0.3209	0.3125	5/16
3/8	24	0.3750	0.3702	0.3479	0.3455	0.3239	0.3185	0.3299	0.3344	0.3479	0.3503	0.3780	0.3834	0.3750	3/8
7/16	20	0.4375	0.4323	0.4050	0.4024	0.3762	0.3699	0.3834	0.3888	0.4050	0.4076	0.4411	0.4473	0.4375	7/16
1/2	20	0.5000	0.4948	0.4675	0.4649	0.4387	0.4324	0.4459	0.4513	0.4675	0.4701	0.5036	0.5098	0.5000	1/2
9/16	18	0.5625	0.5565	0.5264	0.5234	0.4943	0.4873	0.5024	0.5084	0.5264	0.5294	0.5665	0.5735	0.5625	9/16
5/8	18	0.6250	0.6190	0.5889	0.5859	0.5568	0.5498	0.5649	0.5709	0.5889	0.5919	0.6290	0.6360	0.6250	5/8
3/4	16	0.7500	0.7436	0.7094	0.7062	0.6733	0.6656	0.6823	0.6891	0.7094	0.7126	0.7545	0.7622	0.7500	3/4
7/8	14	0.8750	0.8678	0.8286	0.8250	0.7874	0.7786	0.7977	0.8054	0.8286	0.8322	0.8802	0.8889	0.8750	7/8
1		1.0000	0.9928	0.9536	0.9500	0.9124	0.9036	0.9227	0.9304	0.9536	0.9572	1.0052	1.0139	1.0000	1
1 1/8	12	1.1250	1.1170	1.0709	1.0669	1.0228	1.0127	1.0348	1.0438	1.0709	1.0749	1.1310	1.1410	1.1250	1 1/8
1 1/4	12	1.2500	1.2420	1.1959	1.1919	1.1478	1.1377	1.1598	1.1688	1.1959	1.1999	1.2560	1.2660	1.2500	1 1/4
1 1/2	12	1.5000	1.4920	1.4459	1.4419	1.3978	1.3877	1.4098	1.4188	1.4459	1.4499	1.5060	1.5160	1.5000	1 1/2
1 3/4	12	1.7500	1.7420	1.6959	1.6919	1.6478	1.6377	1.6598	1.6688	1.6959	1.6999	1.7560	1.7660	1.7500	1 3/4
2	12	2.0000	1.9920	1.9459	1.9419	1.8978	1.8877	1.9098	1.9188	1.9459	1.9499	2.0060	2.0160	2.0000	2
2 1/4	12	2.2500	2.2420	2.1959	2.1919	2.1478	2.1377	2.1598	2.1688	2.1959	2.1999	2.2560	2.2660	2.2500	2 1/4
2 1/2	12	2.5000	2.4920	2.4459	2.4419	2.3978	2.3877	2.4098	2.4188	2.4459	2.4499	2.5060	2.5160	2.5000	2 1/2
2 3/4	12	2.7500	2.7420	2.6959	2.6919	2.6478	2.6377	2.6598	2.6688	2.6959	2.6999	2.7560	2.7660	2.7500	2 3/4
3	10	3.0000	2.9910	2.9350	2.9305	2.8773	2.8656	2.8917	2.9026	2.9350	2.9395	3.0072	3.0189	3.0000	3

* Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root.

Tolerances and Diameters for Close Fits

Screw threads of the "close fit" class are intended for threaded work of the finest commercial quality (where the thread has practically no backlash), and for light screw-driver fits. In the manufacture of screw thread products belonging in this class, it will be necessary to use precision tools, selected master gages, and many other refinements. This quality of work should, therefore, be used only in cases where requirements of the mechanism being produced are exacting, or where special conditions require screws having a precision fit. In order to secure the fit desired, it may be necessary, in some cases, to select the parts when the product is being assembled.

Maximum Screw above Basic Size—The major diameter and the pitch diameter of the maximum screw of a given diameter and pitch will be above the basic dimensions by the allowance (interference) specified in Table 13.

TABLE 12. ALLOWANCES AND TOLERANCES FOR MEDIUM FIT (SPECIAL)

(Screws, Nuts and Gages)

No. of Thds. per Inch	Allowances, Inches	Extreme or Drawing Pitch Diam. Tolerances, Inches	Master Gage Tolerances			Net Pitch Diameter Tolerances, Inches
			Diameter, Inches,	Lead,* Inches, Plus or Minus	1/2 Angle, Plus or Minus	
80	0.0000	0.0013	0.0002	0.0002	0° 30′	0.0009
72	0.0000	0.0013	0.0002	0.0002	0° 30′	0.0009
64	0.0000	0.0014	0.0002	0.0002	0° 30′	0.0010
56	0.0000	0.0015	0.0002	0.0002	0° 30′	0.0011
48	0.0000	0.0016	0.0002	0.0002	0° 30′	0.0012
44	0.0000	0.0016	0.0002	0.0002	0° 30′	0.0012
40	0.0000	0.0017	0.0002	0.0002	0° 20′	0.0013
36	0.0000	0.0018	0.0002	0.0002	0° 20′	0.0014
32	0.0000	0.0019	0.0002	0.0002	0° 20′	0.0015
28	0.0000	0.0022	0.0003	0.0002	0° 15′	0.0016
24	0.0000	0.0024	0.0003	0.0002	0° 15′	0.0018
20	0.0000	0.0026	0.0003	0.0002	0° 15′	0.0020
18	0.0000	0.0030	0.0004	0.0003	0° 10′	0.0022
16	0.0000	0.0032	0.0004	0.0003	0° 10′	0.0024
14	0.0000	0.0036	0.0004	0.0003	0° 10′	0.0028
13	0.0000	0.0037	0.0004	0.0003	0° 10′	0.0029
12	0.0000	0.0040	0.0004	0.0003	0° 10′	0.0032
11	0.0000	0.0042	0.0004	0.0003	0° 10′	0.0034
10	0.0000	0.0045	0.0004	0.0004	0° 5′	0.0037
9	0.0000	0.0049	0.0004	0.0004	0° 5′	0.0041
8	0.0000	0.0054	0.0004	0.0004	0° 5′	0.0046
7	0.0000	0.0059	0.0004	0.0004	0° 5′	0.0051
6	0.0000	0.0071	0.0006	0.0005	0° 5′	0.0059
5	0.0000	0.0082	0.0006	0.0005	0° 5′	0.0070
4 1/2	0.0000	0.0089	0.0006	0.0005	0° 5′	0.0077
4	0.0000	0.0097	0.0006	0.0005	0° 5′	0.0085

Machinery

*Allowable variation in lead between any two threads not farther apart than the length of engagement.

Direction of Tolerance on Nut and Screw—The tolerance on the nut will be plus and is to be applied from the basic size to above the basic size. The tolerance on the screw will be minus and is to be applied from the maximum screw dimensions to below the maximum screw dimensions.

Allowance and Tolerance Values—The allowance (interference) provided between the size of the minimum nut, which is basic, and the size of the maximum screw, which is above basic, will be as specified in Table 13. The tolerance for a screw or nut of given pitch will be as specified in this same table.

Application of Tolerances

Three different sets of tolerances are given in Tables 4, 5, 12, and 13 for use in connection with the various classes of screw thread fits previously mentioned. The tolerance limits established represent, in reality, the sizes of the "Go" and "Not Go" master gages. Errors in lead and angle which

TABLE 13. ALLOWANCES AND TOLERANCES FOR CLOSE FIT

(Screws, Nuts and Gages)

No. of Thds. per Inch	Interference or Negative Allowances, Inches	Extreme or Drawing Pitch Diam. Tolerances, Inches	Master Gage Tolerances			Net Pitch Diameter Tolerances, Inches
			Diameter, Inches	Lead,* Inches, Plus or Minus	1/2 Angle, Plus or Minus	
80	0.0001	0.0006	0.0001	0.0001	15′ 00″	0.0004
72	0.0001	0.0007	0.0001	0.0001	15′ 00″	0.0005
64	0.0001	0.0007	0.0001	0.0001	15′ 00″	0.0005
56	0.0002	0.0007	0.0001	0.0001	15′ 00″	0.0005
48	0.0002	0.0008	0.0001	0.0001	15′ 00″	0.0006
44	0.0002	0.0008	0.0001	0.0001	15′ 00″	0.0006
40	0.0002	0.0009	0.0001	0.0001	10′ 00″	0.0007
36	0.0002	0.0009	0.0001	0.0001	10′ 00″	0.0007
32	0.0002	0.0010	0.0001	0.0001	10′ 00″	0.0008
28	0.0002	0.0011	0.00015	0.0001	7′ 30″	0.0008
24	0.0003	0.0012	0.00015	0.0001	7′ 30″	0.0009
20	0.0003	0.0013	0.00015	0.0001	7′ 30″	0.0010
18	0.0003	0.0015	0.0002	0.00015	5′ 00″	0.0011
16	0.0004	0.0016	0.0002	0.00015	5′ 00″	0.0012
14	0.0004	0.0018	0.0002	0.00015	5′ 00″	0.0014
13	0.0004	0.0019	0.0002	0.00015	5′ 00″	0.0015
12	0.0005	0.0020	0.0002	0.00015	5′ 00″	0.0016
11	0.0005	0.0021	0.0002	0.00015	5′ 00″	0.0017
10	0.0006	0.0023	0.0002	0.0002	2′ 30″	0.0019
9	0.0006	0.0024	0.0002	0.0002	2′ 30″	0.0020
8	0.0007	0.0027	0.0002	0.0002	2′ 30″	0.0023
7	0.0008	0.0030	0.0002	0.0002	2′ 30″	0.0026
6	0.0009	0.0036	0.0003	0.00025	2′ 30″	0.0030
5	0.0010	0.0041	0.0003	0.00025	2′ 30″	0.0035
4 1/2	0.0011	0.0044	0.0003	0.00025	2′ 30″	0.0038
4	0.0013	0.0048	0.0003	0.00025	2′ 30″	0.0042

Machinery

*Allowable variation in lead between any two threads not farther apart than the length of engagement.

occur on the threaded work can be offset by a suitable alteration of the pitch diameter of the work. If the "Go" gage passes the threaded work, interchangeability is secured and the thread profile may differ from that of the "Go" gage in either pitch diameter, lead, or angle. The "Not Go" gage checks pitch diameter only, and thus insures that the pitch diameter is such that the fit will not be too loose.

The pitch diameter tolerances provided for a screw of a given class of fit are the same as the pitch diameter tolerances provided for a nut corresponding to the same class of fit. The tolerances established for loose and medium fits

The minimum minor diameter of a screw of a given pitch will be such as to result in a basic flat (1/8 × pitch) at the root when the pitch diameter of the screw is at its minimum value. (*Note*: When the maximum screw is basic, the minimum minor diameter of the screw will be below the *basic* minor diameter by the amount of the specified pitch diameter tolerance.)

The maximum minor diameter may be such as results from the use of a worn or rounded threading tool, when the pitch diameter is at its maximum value. In no case, however, should the form of the screw, resulting from tool wear, be

TABLE 14. CLOSE FIT—NATIONAL COARSE THREAD SERIES

Numbered and Fractional Sizes	No. of Threads per Inch	Screw Sizes						Nut Sizes						Basic Major Diam., Inches	Numbered and Fractional Sizes
		Major Diam.		Pitch Diam.		Minor Diam.		Minor Diam.		Pitch Diam.		Major Diam.			
		Max. Inches	Min. Inches	Max. Inches	Min. Inches	Max.* Inches	Min. Inches	Min. Inches	Max. Inches	Min. Inches	Max. Inches	Min.* Inches	Max. Inches		
1	64	0.0731	0.0717	0.0630	0.0623	0.0539	0.0521	0.0561	0.0578	0.0629	0.0636	0.0741	0.0760	0.0730	1
2	56	0.0862	0.0848	0.0746	0.0739	0.0643	0.0623	0.0667	0.0686	0.0744	0.0751	0.0873	0.0893	0.0860	2
3	48	0.0992	0.0976	0.0857	0.0849	0.0736	0.0713	0.0764	0.0787	0.0855	0.0863	0.1005	0.1028	0.0990	3
4	40	0.1122	0.1104	0.0960	0.0951	0.0815	0.0788	0.0849	0.0876	0.0958	0.0967	0.1138	0.1165	0.1120	4
5	40	0.1252	0.1234	0.1090	0.1081	0.0945	0.0918	0.0979	0.1006	0.1088	0.1097	0.1268	0.1295	0.1250	5
6	32	0.1382	0.1362	0.1179	0.1169	0.0999	0.0966	0.1042	0.1076	0.1177	0.1187	0.1403	0.1435	0.1380	6
8	32	0.1642	0.1622	0.1439	0.1429	0.1259	0.1226	0.1302	0.1336	0.1437	0.1447	0.1663	0.1695	0.1640	8
10	24	0.1903	0.1879	0.1632	0.1620	0.1392	0.1350	0.1449	0.1494	0.1629	0.1641	0.1930	0.1972	0.1900	10
12	24	0.2163	0.2139	0.1892	0.1880	0.1652	0.1610	0.1709	0.1754	0.1889	0.1901	0.2190	0.2232	0.2160	12
1/4	20	0.2503	0.2477	0.2178	0.2165	0.1890	0.1840	0.1959	0.2013	0.2175	0.2188	0.2536	0.2585	0.2500	1/4
5/16	18	0.3128	0.3098	0.2767	0.2752	0.2446	0.2391	0.2524	0.2584	0.2764	0.2779	0.3165	0.3220	0.3125	5/16
3/8	16	0.3754	0.3722	0.3348	0.3332	0.2987	0.2926	0.3073	0.3141	0.3344	0.3360	0.3795	0.3856	0.3750	3/8
7/16	14	0.4379	0.4343	0.3915	0.3897	0.3503	0.3433	0.3602	0.3679	0.3911	0.3929	0.4427	0.4496	0.4375	7/16
1/2	13	0.5004	0.4966	0.4504	0.4485	0.4059	0.3986	0.4167	0.4251	0.4500	0.4519	0.5056	0.5131	0.5000	1/2
9/16	12	0.5630	0.5590	0.5089	0.5069	0.4608	0.4527	0.4723	0.4813	0.5084	0.5104	0.5685	0.5765	0.5625	9/16
5/8	11	0.6255	0.6213	0.5665	0.5644	0.5140	0.5053	0.5266	0.5364	0.5660	0.5681	0.6316	0.6403	0.6250	5/8
3/4	10	0.7506	0.7460	0.6856	0.6833	0.6279	0.6184	0.6417	0.6526	0.6850	0.6873	0.7572	0.7667	0.7500	3/4
7/8	9	0.8756	0.8708	0.8034	0.8010	0.7393	0.7289	0.7547	0.7667	0.8028	0.8052	0.8830	0.8934	0.8750	7/8
1	8	1.0007	0.9953	0.9195	0.9168	0.8473	0.8356	0.8647	0.8782	0.9188	0.9215	1.0090	1.0207	1.0000	1
1 1/8	7	1.1258	1.1198	1.0330	1.0300	0.9505	0.9372	0.9704	0.9858	1.0322	1.0352	1.1353	1.1486	1.1250	1 1/8
1 1/4	7	1.2508	1.2448	1.1580	1.1550	1.0755	1.0622	1.0954	1.1108	1.1572	1.1602	1.2603	1.2736	1.2500	1 1/4
1 1/2	6	1.5009	1.4937	1.3926	1.3890	1.2964	1.2808	1.3196	1.3376	1.3917	1.3953	1.5120	1.5277	1.5000	1 1/2
1 3/4	5	1.7510	1.7428	1.6211	1.6170	1.5056	1.4871	1.5335	1.5551	1.6201	1.6242	1.7644	1.7830	1.7500	1 3/4
2	4 1/2	2.0011	1.9923	1.8568	1.8524	1.7285	1.7080	1.7594	1.7835	1.8557	1.8601	2.0160	2.0365	2.0000	2
2 1/4	4 1/2	2.2511	2.2423	2.1068	2.1024	1.9785	1.9580	2.0094	2.0335	2.1057	2.1101	2.2660	2.2865	2.2500	2 1/4
2 1/2	4	2.5013	2.4917	2.3389	2.3341	2.1946	2.1717	2.2294	2.2564	2.3376	2.3424	2.5180	2.5409	2.5000	2 1/2
2 3/4	4	2.7513	2.7417	2.5889	2.5841	2.4446	2.4217	2.4794	2.5064	2.5876	2.5924	2.7680	2.7909	2.7500	2 3/4
3	4	3.0013	2.9917	2.8389	2.8341	2.6946	2.6717	2.7294	2.7564	2.8376	2.8424	3.0180	3.0409	3.0000	3

* Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root.

TABLE 15. CLOSE FIT—NATIONAL FINE THREAD SERIES

Numbered and Fractional Sizes	No. of Threads per Inch	Screw Sizes						Nut Sizes						Basic Major Diam., Inches	Numbered and Fractional Sizes
		Major Diam.		Pitch Diam.		Minor Diam.		Minor Diam.		Pitch Diam.		Major Diam.			
		Max. Inches	Min. Inches	Max. Inches	Min. Inches	Max.* Inches	Min. Inches	Min. Inches	Max. Inches	Min. Inches	Max. Inches	Min.* Inches	Max. Inches		
0	80	0.0601	0.0589	0.0520	0.0514	0.0448	0.0433	0.0465	0.0478	0.0519	0.0525	0.0609	0.0624	0.0600	0
1	72	0.0731	0.0717	0.0641	0.0634	0.0561	0.0544	0.0580	0.0595	0.0640	0.0647	0.0740	0.0757	0.0730	1
2	64	0.0861	0.0847	0.0760	0.0753	0.0669	0.0651	0.0691	0.0708	0.0759	0.0766	0.0871	0.0890	0.0860	2
3	56	0.0992	0.0978	0.0876	0.0869	0.0773	0.0753	0.0797	0.0816	0.0874	0.0881	0.1003	0.1023	0.0990	3
4	48	0.1122	0.1106	0.0987	0.0979	0.0866	0.0843	0.0894	0.0917	0.0985	0.0993	0.1135	0.1158	0.1120	4
5	44	0.1252	0.1236	0.1104	0.1096	0.0973	0.0949	0.1004	0.1029	0.1102	0.1110	0.1266	0.1289	0.1250	5
6	40	0.1382	0.1364	0.1220	0.1211	0.1075	0.1048	0.1109	0.1136	0.1218	0.1227	0.1398	0.1425	0.1380	6
8	36	0.1642	0.1624	0.1462	0.1453	0.1301	0.1272	0.1339	0.1369	0.1460	0.1469	0.1660	0.1689	0.1640	8
10	32	0.1902	0.1882	0.1699	0.1689	0.1519	0.1486	0.1562	0.1596	0.1697	0.1707	0.1923	0.1955	0.1900	10
12	28	0.2162	0.2140	0.1930	0.1919	0.1724	0.1687	0.1773	0.1812	0.1928	0.1939	0.2186	0.2223	0.2160	12
1/4	28	0.2502	0.2480	0.2270	0.2259	0.2064	0.2027	0.2113	0.2152	0.2268	0.2279	0.2526	0.2563	0.2500	1/4
5/16	24	0.3128	0.3104	0.2857	0.2845	0.2617	0.2575	0.2674	0.2719	0.2854	0.2866	0.3155	0.3197	0.3125	5/16
3/8	24	0.3753	0.3729	0.3482	0.3470	0.3242	0.3200	0.3299	0.3344	0.3479	0.3491	0.3780	0.3822	0.3750	3/8
7/16	20	0.4378	0.4352	0.4053	0.4040	0.3765	0.3715	0.3834	0.3888	0.4050	0.4063	0.4411	0.4460	0.4375	7/16
1/2	20	0.5003	0.4977	0.4678	0.4665	0.4390	0.4340	0.4459	0.4513	0.4675	0.4688	0.5036	0.5085	0.5000	1/2
9/16	18	0.5628	0.5598	0.5267	0.5252	0.4946	0.4891	0.5024	0.5084	0.5264	0.5279	0.5665	0.5720	0.5625	9/16
5/8	18	0.6253	0.6223	0.5892	0.5877	0.5571	0.5516	0.5649	0.5709	0.5889	0.5904	0.6290	0.6345	0.6250	5/8
3/4	16	0.7504	0.7472	0.7098	0.7082	0.6737	0.6676	0.6823	0.6891	0.7094	0.7110	0.7545	0.7606	0.7500	3/4
7/8	14	0.8754	0.8718	0.8290	0.8272	0.7878	0.7807	0.7977	0.8054	0.8286	0.8304	0.8802	0.8872	0.8750	7/8
1	14	1.0004	0.9968	0.9540	0.9522	0.9128	0.9058	0.9227	0.9304	0.9536	0.9554	1.0052	1.0121	1.0000	1
1 1/8	12	1.1255	1.1215	1.0714	1.0694	1.0233	1.0152	1.0348	1.0438	1.0709	1.0729	1.1310	1.1390	1.1250	1 1/8
1 1/4	12	1.2505	1.2465	1.1964	1.1944	1.1483	1.1402	1.1598	1.1688	1.1959	1.1979	1.2560	1.2640	1.2500	1 1/4
1 1/2	12	1.5005	1.4965	1.4464	1.4444	1.3983	1.3902	1.4098	1.4188	1.4459	1.4479	1.5060	1.5140	1.5000	1 1/2
1 3/4	12	1.7505	1.7465	1.6964	1.6944	1.6483	1.6402	1.6598	1.6688	1.6959	1.6979	1.7560	1.7640	1.7500	1 3/4
2	12	2.0005	1.9965	1.9464	1.9444	1.8983	1.8902	1.9098	1.9188	1.9459	1.9479	2.0060	2.0140	2.0000	2
2 1/4	12	2.2505	2.2465	2.1964	2.1944	2.1483	2.1402	2.1598	2.1688	2.1959	2.1979	2.2560	2.2640	2.2500	2 1/4
2 1/2	12	2.5005	2.4965	2.4465	2.4444	2.3983	2.3902	2.4098	2.4188	2.4459	2.4479	2.5060	2.5140	2.5000	2 1/2
2 3/4	12	2.7505	2.7465	2.6964	2.6944	2.6483	2.6402	2.6598	2.6688	2.6959	2.6979	2.7560	2.7640	2.7500	2 3/4
3	10	3.0006	2.9960	2.9356	2.9333	2.8779	2.8684	2.8917	2.9026	2.9350	2.9373	3.0072	3.0167	3.0000	3

* Dimensions given are figured to the intersection of the worn tool arc with a center line through crest and root.

permit the use of commercial taps. For close fits, when it is desired to produce a hole close to basic size, the use of a selected tap is recommended.

Tolerances on Major and Minor Diameters of Screw

The allowable tolerances on the major diameter of screws of a given classification will be twice the tolerance values allowed on the pitch diameters of screws of the same class.

such as to cause the screw to be rejected on the maximum minor diameter by a "Go" ring gage, the minor diameter of which is equal to the minimum minor diameter of the nut.

Tolerances on Major and Minor Diameters of Nut

The maximum major diameter of the nut of a given pitch will be such as to result in a flat 1/3 of the basic flat (1/24

× pitch) when the pitch diameter of the nut is at its maximum value. (*Note*: When the minimum nut is basic, the maximum major diameter will be above the *basic* major diameter by the amount of the specified pitch diameter tolerance plus 2/9 of the basic thread depth.)

The nominal minimum major diameter of a nut will be above the basic major diameter by an amount equal to 1/9 of the basic thread depth plus the neutral space. This results in a clearance which is provided to facilitate manufacture by permitting a slight rounding or wear at the crest of the tap. In no case, however, should the minimum major diameter of the nut, resulting from a worn tap or cutting tool, be such as to cause the nut to be rejected on the minimum major diameter by a "Go" plug gage made to the standard form at the crest.

The tolerances on the minor diameter of a nut of a given pitch will be 1/6 of the basic thread depth regardless of the class of fit being produced.

Scope of Tolerance Specifications

The specifications establishing the various sets of tolerances for different classes of screw thread fits will apply to the manufacture of National coarse threads, National fine threads, National hose coupling threads, National fire hose coupling threads, straight pipe threads, and wherever applicable to the production of all special threads.

When tolerances are desired for a special thread and the pitch is not listed in the tables given, the tolerance values should be chosen corresponding to the number of threads per inch nearest to that of the special thread being produced. When the number of threads per inch is midway between two of the pitches listed, the tolerance corresponding to the coarser pitch should be used. For instance, the tolerance on a screw having 11½ threads per inch would correspond to the tolerances specified for a screw of 11 threads per inch.

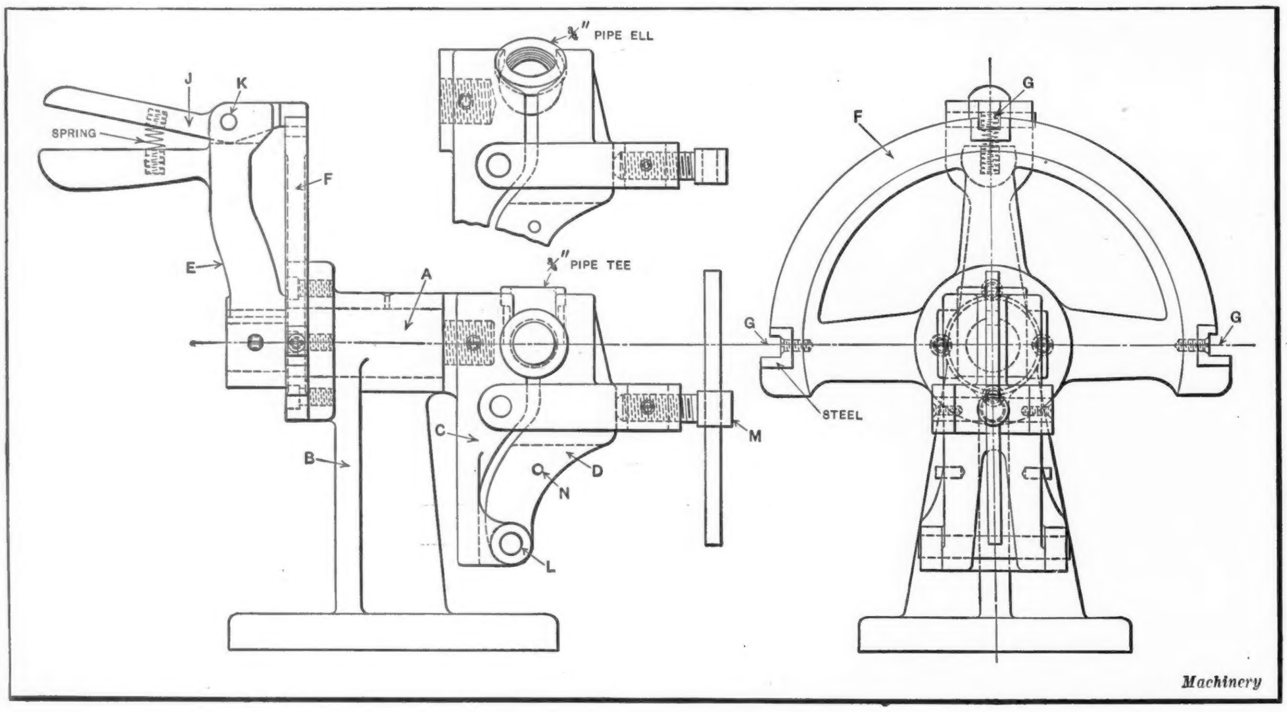
Concluding Remarks

The work of the National Screw Thread Commission has been very thorough, and the report presented is an exhaustive study of the whole subject. When the commission started its work, it held hearings in all of the larger industrial centers of the country and obtained in this way suggestions from a great many manufacturers and engineers. No effort was spared in obtaining all the information necessary to present a report that would be acceptable to all concerned.

JIG USED IN REAMING AND TAPPING PIPE TEES AND ELLS

By J. C. KING

A jig for use in holding pipe tees and ells during reaming and tapping operations is shown in the accompanying illustration. This jig is of the indexing type, its construction being clearly shown in the illustration. The cast-iron base *B* contains a bearing in which the arbor *A* is a slip fit. Jaw *C* is attached to the threaded end of this arbor by means of a set-screw, while the mating jaw *D* hinges on the lower end of the fixed jaw, to which it is assembled by means of the pin *L*. Both the fixed jaw *C* and the hinged jaw *D* are made of cast iron and are designed to conform to the size and shape of the part being machined. A crank handle *E* is keyed and fastened by a screw to the opposite end of the arbor and is located parallel with the vertical center line of the jaws. A 180-degree cast-iron quadrant *F*, which is provided with three steel-lined stops *G*, is mounted on the base by means of four machine screws as shown. It will be seen that these stops are spaced 90 degrees apart on the periphery of the quadrant; this enables the machined surfaces of the tees and ells to be accurately located in relation to each other when the parts are being reamed or tapped. It will be evident that by releasing pawl *J*, which is hinged to crank *E* by means of pin *K*, the fixture may be readily indexed to the desired position.



Indexing Jig for holding Pipe Tees and Ells

A quick clamping arrangement is employed for securing the work in place and for releasing it after being machined. This clamping device is hinged to jaw *C* and is operated by the pilot screw *M*, which, when released, enables the clamp to drop down against stops *N* and the jaw *D* to fall away from engagement with the tee or ell, as the case may be. The illustration also shows a partial view of the jaws as they would be designed for holding a 90-degree ell. Care must be exercised in mounting the jaws, particularly in the case of the ells, to position them so that the center lines of the stops *G* on the quadrant will be coincident with those of the holes in the pipe part.

In a concern where this jig is in daily use, 150 tees are reamed and tapped per hour, which represents an increase in the production rate of 87 per cent, the previous output when using a stationary jig being but 80 pieces per hour. In the case of ells, 175 pieces may be machined per hour as against 100 per hour by the old method.

The British Machine Tool Industry

From MACHINERY'S Special Correspondent

London, June 14

THE trade in machine and small tools in this country shows a steady tendency toward stability. The great influx of imports, the majority from the United States, rendered necessary by the artificial conditions in existence during and immediately after the war has now decreased to a figure more nearly comparable with exports. To compare the present trade with that before the war is impossible, the relative and varying money values alone preventing deductions being made that could carry any weight. Except in a few cases, all machine tool makers report a heavy home and continental demand. The exceptions state that the enormous sales of government machine tools have had a depressing effect on the market; that the effect should only be felt in a few instances is an indication of the phenomenal activity in buying. Before the war the value of machine tool exports was roughly four times that of imports; at the present time the export value is only 60 per cent of the import value.

Labor Conditions

Labor appears to be slowly settling down to more stable conditions. The principle of payment by results, although accepted by several branches of workers, has for the moment been repudiated by the Amalgamated Society of Engineers which has a large following of skilled mechanics. There is a strong antagonism to over-time throughout most of the trade unions; consequently the most urgent work cannot be expedited in this way. The men generally earn enough to live comfortably and the incentive of over-time is not as strong as in pre-war days. Iron founders in many districts find a shortage of suitable labor, and this greatly retards the efforts made to catch up some of the time lost by the recent disastrous strike. The arguments used by the labor spokesmen to the effect that decreased working hours would result in increased work being turned out is not borne out by results, and the Association of British Chambers of Commerce may appeal to the unions to agree temporarily to a longer working day. If successful, part of the demand for British machine tools throughout the world might be satisfied. In the Midlands, machine tool makers are very hopeful, since the supply of castings in this district has improved considerably, and a continuation of the present supply would enable early delivery of machines in arrears. During the molders' strike, many machine shops had to close certain departments because the lack of castings threw a great many men out of employment. This condition is now practically remedied.

Prices of Machine Tools

The prices of machine tools in this country are at the present time more stable than for some time past. In the heavier machines, the increasing price of castings is still felt, but generally quotations can be made with more certainty. The American exchange, which today is in the neighborhood of $3.80 to the pound, is a rather heavy handicap in the sale of American tools in this country. Previously, better deliveries have been obtainable from the United States, but with slowly improving conditions in supply, home deliveries are improving decidedly. Best quality machine tool castings cost 44 shillings per hundredweight, and steel has kept fairly constant during the last month, round stock averaging £27 per ton.

Developments in the Machine Tool Trade

The developments in the machine tool trade are numerous. The Birmingham Small Arms Co., of Sparbrook, has planned to assist in the equipment of manufacturers not only by supplying the jigs, fixtures, and tools they may require, but also by advising as to methods that should be used in the manufacture of any product from start to finish. Cammell Laird & Co., Ltd., Sheffield, are devoting to commercial work the whole of their great plant at Sheffield and Penistone with the exception of the armor plate department. Extensions to their Penistone works will enable a total of 7000 tons of steel per week to be produced on the Bessemer-acid and Siemens hearth processes. In the Govan district of Scotland the shipyards and works of Harland & Wolff are being extended considerably, and similar remarks apply to the Fairfield Shipbuilding Co., while a new steel works is being put up at Motherwell, Scotland. George Richards & Co., Ltd., of Broadheath in the Manchester district, are, in common with many other firms, building and equipping a foundry for the production of their own castings. The Lapointe Machine Tool Co., of Hudson, Mass., U. S. A., is equipping a factory in the London district for the supply of broaching tools and equipment to English users of their broaching machines.

New Machine Tools

A new boiler flue mouth boring and facing machine has been turned out by G. & A. Harvey, Ltd., of Govan. The machine, which has a box section column, is of substantial proportions, weighing 11 tons. Power is taken from a 10-horsepower variable-speed motor. The machine spindle, which is carried horizontally on a rising and falling carriage, carries a large flange to which the driving wheel and tool-slide are secured. The same firm has also recently completed a turbine boring machine with a work-plate 19 feet 6 inches long by 9 feet wide. Special facilities have been provided for making tool adjustment without interrupting the operation of the machine.

A new type of vertical turning and boring mill has been produced by Joshua Buckton & Co., Ltd., Leeds, which is capable of machining, all over, an oil-treated steel tire of 4 feet 5 inches in diameter by 5½ inches wide in 115 minutes. A depth of about ¼ inch of metal was removed from the entire surface. The machine, which is driven by a 25-horsepower motor, will admit 20 inches beneath the cross-slide, and the work is held by self-centering chuck jaws. Two tools are used simultaneously for boring and turning. The 500-ton boiler flanging presses made by Henry Berry & Sons, Ltd., of Leeds have three hydraulic cylinders in the base and one movable cylinder in the head; the mobility of the head cylinder allows pressure to be concentrated at any particular part of a job and is useful in plate straightening or for forming operations at a distance from the center. A clear space of 12 feet is available between the press uprights.

J. W. Barnes, Ltd., Rock Ferry, has introduced an electrically driven scarfing machine which is particularly useful for cutting propeller shaft keyways, scarfing boiler and ship plates, and for other jobs where the machine must go to the work. A forging furnace heated on the regenerative principle has been introduced by the Davis Furnace Co., of Luton. The normal working temperature of 1300 degrees C. is attained from cold in fifty minutes, and eight ¾-inch bars can be brought to welding heat every minute.

Building a Permanent Organization

By WILLIAM H. McGREGOR, President, National Twist Drill & Tool Co., Detroit, Mich.

The harmonious relations existing at the plant of the National Twist Drill & Tool Co., in Detroit, Mich., are of such interest at this time when labor problems are attracting the attention of the entire industrial world, that MACHINERY has requested the president of the company, William H. McGregor, to prepare, for the benefit of the readers, an outline of the methods employed for furthering friendly relations between employer and employes, and for the building up of a permanent organization to which the men and women employed would have a greater attachment than that produced by mere employment in a manufacturing plant.

In the building of a permanent organization in which the various members will work harmoniously with each other and in which they will give their best efforts to the furtherance of the interests of the firm for which they are working, it is necessary to provide some means whereby those men and women upon whose efforts the results mainly depend, or whose loyalty has become an actual asset to the company, may acquire a definite financial interest in the concern. Steps were therefore taken by the National Twist Drill & Tool Co. with a view to permitting the men and women occupying responsible positions in the office or factory, to acquire stock in the company at a price less than the prevailing market price and upon terms of payment making it possible for them to become partners in the enterprise, by extending the payments over a period of years. In view of the fact that the stock is sold at less than market price, the buyer does not take title to it until five years have elapsed from the date of sale, and at that time, if he is still in the employ of the company, he becomes the absolute owner of the stock, all dividends that have become due in the meantime having been credited to his account. At the present time about thirty-five of the men and women in the company's employ who either hold responsible positions, or, who by length of service and loyalty have made themselves deserving of special consideration, have become stockholders of the company in this manner. It is intended gradually to extend this plan still further so that a constantly increasing number of employes may become financially interested in the company.

Promotions within the Organization

The company has about 800 employes of which about 200 are women. As the stock-owning proposition cannot apply to all of these, the company has endeavored to gain their loyalty and cooperation by such means as will insure everyone of the fairness and good faith of the employer. One of the effective means of doing this has been to promote to better positions from within the organization whenever possible. The office and the factory are treated alike. They are both placed under the same manager, and there is no well defined line between the two such as is found in many industrial organizations. It has been the policy of the company to promote girls from the factory to office positions whenever they have proved capable of performing work of the kind required. The general procedure is to first promote the girls from the factory to the factory office, and then from the factory office to the main or sales office.

This does not apply to women employes only, but applies to the whole working force. Every office employe begins his career in the factory, and young men are carefully selected to learn their trade in the shop with the idea that they ultimately may occupy executive positions within the organization. An effort is made for this purpose to obtain bright young men of high-school or college education, and place them for a couple of years in the factory. Their abilities and inclinations are then watched, and as the opportunity presents itself, they are promoted to positions for which they prove themselves fitted. Every executive now in the organization has reached his present position in this manner, which insures that everyone is thoroughly familiar with the work of the whole organization, and a homogeneous working force that can cooperate intelligently, is the result. It is also easy, in this manner, to place every man in a position that is exactly right for him. He is not hired from the outside to fill a certain job for which he may prove unsuited and from which it may be difficult to transfer him; but he is gradually brought into the position for which he is best fitted in the organization by a thorough study of his natural bent and capacity.

The Problem of Woman Labor

The employment of women has been considered a difficult problem in many factories. This is largely because the matter is not approached in the right manner. The National Twist Drill & Tool Co. has had no difficulty along these lines. On the contrary, this company has found the employment of the right kind of women an asset. A special effort has been made to take care of the welfare and comfort of the women employed, and a matron is provided who acts as an advisory counsel to the girls and who aids them in all matters that they care to bring to her attention. She looks after their interests in many ways and often acts as an intermediary in cases of differences between the girls and their foremen. A special effort is made to obtain a high grade of women for the factory. The method generally followed is to obtain new employes through present employes who have made a good record for themselves. A high-grade girl already employed is not likely to recommend another girl for employment, unless she is of her own standard, and in this way a high-class working force has been acquired. By the employment of a high grade of women, it is also possible to obtain a better class of men in the shop, and the men soon learn to act as gentlemen in all their relations with the women employed. There have been many cases of marriage between employes, and, as a rule, the man remains permanently with the concern, as both he and his wife have a more definite interest in the firm than they would have if he had married a girl who knew nothing about the place where he was working.

The Foreign-born Worker

During and since the war, the problem of the foreign-born worker has been given more attention than formerly. As a matter of fact, the foreign-born worker does not present any serious problem, provided the matter is properly handled. It has not been found advisable to place foreign-born men as foremen over departments where the majority of the men or women would be of their own nationality. This is a principle generally appreciated in the industries, as it has always been found unsatisfactory to have a department composed nearly or entirely of one nationality. It is much better to have various nationalities mixed; this avoids clannishness and promotes Americanization.

A definite effort is made to encourage all foreign-born workers to become American citizens. The public schools of Detroit maintain excellent evening schools in which the foreign-born worker may acquire a good knowledge of the English language, and a similar school is also maintained by the Y. M. C. A. The foreign-born workers who have not ac-

quired a knowledge of the English language are encouraged to attend these schools. Men of their own nationality, who are already citizens, are also selected in various departments to coach these men both as regards Americanization in general and citizenship. The employment bureau furnishes all information required by the men with regard to obtaining citizenship papers, and the men are paid for time lost in attending to naturalization.

Another feature which greatly encourages the foreign-born worker to become an American citizen is that the company maintains a group insurance for its employes, but this insurance applies only to American citizens. Any man in the company's employ, who is an American citizen, is automatically insured after six months of service for $500, this insurance increasing gradually up to $1000 after five years of service. In addition to the insurance feature, the firm allows men of good standing to borrow from the company on their insurance policies, in case of urgent need. This privilege is especially extended in cases of elderly men or employes who have been long in the company's service, when through misfortune they may happen to be in urgent need of money.

Providing for the Health and Welfare of the Workers

In order to provide for the health of the workers, the company maintains a shop hospital which is visited by a doctor one hour in the morning each day, and which is in charge of a nurse at all times. As the doctor in charge maintains an office but one block away from the factory, he is within call at practically all times, and the men and women employed receive, in this manner, all ordinary medical attendance free of charge, and all injuries are treated immediately and are properly cared for.

The company also maintains a restaurant where the noonday meal is served at the actual wholesale cost of the food alone. In this manner, meals can be served at less than one-half the price that the ordinary restaurant would have to charge. The price charged for meals naturally has to be set at a figure that will provide for a small margin, so as to prevent any direct loss, but the surplus that is created is converted into a sickness fund for the women employes.

A savings arrangement has also been put into effect by means of which any woman employe who puts into the saving fund a specified amount per week, will have this amount doubled by the company, provided she keeps up the saving for fifty consecutive weeks. Punctuality and regularity of attendance is encouraged in the case of women employes by the payment of 10 per cent of their wages additional weekly, provided they have a perfect punctuality and attendance record. Absence of one hour per week is allowed under this rule, and in certain cases exceptions are also made for sickness.

The company owns a number of individual houses as well as apartment houses, and as the factory is located in a residential district, these houses are within easy reach of the factory. These houses and apartments are rented to employes, and at the present time, with the great scarcity of houses in Detroit as elsewhere, this feature is of great importance in taking care of the interests of the workers.

General Methods of Management

The general management of the factory is in the hands of a committee of five men, of which Howard L. McGregor, assistant to the president, is chairman. Mr. McGregor is also in general charge of both office and factory, it having already been pointed out that both of these branches of the organization are in charge of the same man. The management committee, in addition, consists of the production manager, the chief engineer, the mechanical manager, and one department foreman. If any man in the shop has any grievance, he takes it up directly with the chairman of this committee, and the committee, in turn, investigates the matter and endeavors to settle it to the satisfaction of all concerned, making the reasons for their decisions clear, and endeavoring to have everybody understand their viewpoint.

A special effort is made to prevent men who are properly filling their positions from leaving the organization. If a man gives notice that he expects to change his job, he is not told to obtain his pay from the pay-master, but instead the assistant to the president has a talk with him to find out definitely the reasons for his wanting to leave, and if the matter can be so arranged that it will be satisfactory for the man to remain, every reasonable effort is made to meet his wishes. It is recognized that a satisfactory employe who has been with the company for some time is an asset, and that it is worth while retaining his services and good will. Too few manufacturers, in general, recognize this, and they seem to consider the number of men on the payroll rather than their qualifications and training. The cost of hiring and training new men constitutes a great waste in American industries, and the value of the asset of a permanent working force is not as thoroughly appreciated as it ought to be. By the methods outlined above, it has been possible for the National Twist Drill & Tool Co. to build up an organization of executives and employes that work together in a harmonious manner and whose loyalty to the company is best evidenced by the number of years that many of them have been in its service.

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PAPER REPORT OF SENATE COMMITTEE

Readers in the mechanical field will be interested in the striking report and recommendations of the Senate Subcommittee which has been investigating the vitally important subject of paper. MACHINERY is paying more than a 300 per cent increase in the price of the paper it uses and an even higher percentage for book papers; and is warned that paper prices are going still higher. The searching investigation of the Senate Committee showed that while there is a scarcity of the wood pulp which forms the basis of paper manufacture, there has been and still is heavy profiteering in the paper market. Workers in every field are vitally interested in the cost and supply of paper—the medium of the printed word.

Paper manufacturers are accused by the committee of "unjust, illegal, and discriminatory practices," and present prices for newsprint paper are held to be "excessive and unwarranted." The recommendations for remedying this situation include provision for the small publishers to obtain paper from the mills at a minimum cost, placing print paper under the restrictions of the Lever food control act, and establishing an experimental fund for the discovery of a substitute for wood in the manufacture of pulp. The committee took into consideration the various disturbing elements that the newspaper industry has been subjected to during war-time and the subsequent period of rising material and labor costs, as well as the increased consumption of print paper, the apparent scarcity of wood pulp, and other unstabilizing factors common to all lines of business at the present time. Notwithstanding these conditions, the evidence indicated that "the scarcity of the product was more the result of artificial obstructions than of natural laws." This is a matter of importance to everyone, because of the universal dependence upon periodicals and books for supplying news and information which is so essential to national development.

* * *

The Carnegie Steel Co. has offered to aid its employes in acquiring homes by selling them homes owned by the company, with an initial payment of 15 per cent of the purchase price and the remainder in monthly installments over a period of ten years, interest on deferred payments to be paid at the rate of 5 per cent per year; or by purchasing homes for employes from private owners; or by building them homes directly; or by a mortgage plan, the loan not to exceed 75 per cent of the property cost and to be payable over a period of ten years with interest at 5 per cent.

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INCREASED USE OF DIE-CASTINGS

The high cost of labor is one reason for the increasing use of die-castings in mechanical devices where the strength and wearing qualities of the metals that can be die-cast are satisfactory. Manufacturers who formerly employed parts machined from steel find it necessary to use die-castings to avoid the labor cost of machining. In this respect the die-casting process occupies a somewhat similar place in the machine industry to that of the automatic machine.

To produce die-castings accurately requires intricate dies and complicated machinery, and in the diemaking and the building of this machinery highly skilled and high-priced labor is employed; but when the dies and the machines are once made, thousands of duplicate parts can be produced at a small labor cost. Conditions affecting the use of the automatic screw machine are similar. The machine is expensive and the tools must be produced by skilled and high-priced labor, but when the machine is once set up for the production of any part in quantity, it will continue to produce that part by thousands and tens of thousands with a minimum of attendance and at a very low labor cost.

Rising labor costs continually force the manufacturer and the engineer to devise new means for producing cheaply and with a minimum amount of manual labor. It is nothing new to say that the high development of the machine-building industries in the United States has been due largely to the high wages paid here, which forced the introduction of labor-saving and automatic machinery. The process of development is still going on, and a large new field has been opened up through the introduction of die-casting. If this new art were unknown, many of the instruments and mechanisms now so commonly used, such as speedometers and phonographs, would be much higher in price and would not be manufactured and used to the extent that they now are.

* * *

BUILDING VERSUS MANUFACTURING MACHINERY

When machines are produced one at a time, the parts for each machine being fitted together individually, we say that they are "built." When they are made in quantities, the parts all being interchangeable and every part exactly like every other corresponding part, they are "manufactured." This distinction was brought out by Henry M. Leland in a recent statement on the making of automobile engines in Germany and here in 1913. At that time, in a large German automobile factory where automobiles were "built," fifteen engines a day were assembled in a department four times as large as the assembling department of a certain Detroit automobile factory, and employing five times as many men as the latter. In the Detroit factory one hundred engines a day of the same type and general quality were assembled.

The difference was simply one of method. In the Detroit factory all the parts were made alike on an interchangeable basis and carefully inspected before they entered the assembling room to insure their interchangeability. In the German factory the parts, not being made on the interchangeable basis, were not exactly alike, and in assembling the engines had to be fitted together, with great waste of labor.

But this is not the whole story: If a part breaks in the engine that has been fitted, another part cannot be bought with the certainty that it will fit accurately into the place it is intended for. It will be necessary to employ a mechanic to put it in place, as a certain amount of fitting must be done. When a part breaks on a car made on the interchangeable basis, another part can be bought that will fit right into its place. And it costs less to manufacture on the interchangeable basis, because the additional cost of making all parts alike is negligible with the latest manufacturing methods, while the cost of assembling, if the parts are not interchangeable, may easily be several hundred per cent more.

* * *

POWER PRESS CASUALTIES

Although much has been done to prevent accidents caused by the power press, it still remains the most dangerous machine in the metal-working trades, according to a statement made by August L. Kaems of the Industrial Commission of Wisconsin in a paper read before the Eighth Annual Safety Congress. The accidents caused by power presses are not only more frequent, but are also more serious than those resulting from the operation of other machine tools. In the state of Wisconsin, in one year, 27 per cent of all the accidents in the metal trades, and 48 per cent of all the serious accidents resulting in permanent disability were caused by power presses. This would indicate that while the campaign for safeguarding machines in metal-working plants has been effective in many directions, many safeguards must still be provided for the most dangerous machines.

It was stated in the paper referred to that in one plant alone thirteen fingers had been lost during a period of six months; and what is more significant, the general superintendent of the plant did not know that this number of accidents had taken place. The plant had a "welfare man" who saw that the injured men received proper medical treatment and who also took care that the compensation required by law was paid. It is evident, however, that there is something lacking in the safety system of a plant when the general superintendent can remain ignorant of so many serious accidents. Suppose that instead of thirteen fingers having been lost, material had been spoiled in the process of manufacture, amounting in dollars and cents, to as much as the compensation paid to the victims of the accidents. In that case, doubtless, a report would have been made to the superintendent and an investigation held to determine how from \$5000 to \$6000 worth of material had been wasted.

The interest in the campaign for safety in the industries must not be permitted to lag for, while accidents have been cut down considerably during the past ten years, there is still room for improvement.

Designing Planer Driving Gears

Methods Used in Proportioning Planer Driving Gears, and Tables Giving Dimensions of Various Planer Drives

By W. C. STEUART, Chief Engineer, Detrick & Harvey Plant, Bethlehem Steel Co., Baltimore, Md.

THERE are at present no standard rules for calculating the strength of gears used in transmitting power to the table of a planer, and until someone evolves formulas for determining the strength of heavy slow-running gears, it will be necessary, when designing planer drives, to rely upon the experiences of the leading machine tool builders who manufacture machines of this type. While the Lewis spur gear formula is excellent for gears running at medium or high speeds, it cannot be used in calculating the proportions of gears running at from about 25 revolutions per minute down to a fraction of a revolution. If an attempt were made to proportion the bull gear of a planer, transmitting 100 horsepower at a peripheral speed of 18 feet per minute, by means of this formula, it would be found that the gear would be much too large for the machine. The purpose of this article is to give an idea of the size of the gears required to drive a given size of planer, to point out the difficulties encountered in proportioning the gears so as to obtain the proper ratio of speeds, and to explain the general principles involved in the design of these gears.

One point that is often a stumbling block to the inexperienced designer is the fact that the size of the bull gear has no influence on the speed of the table or on the ratios of the other gears. A little study will show that the speed of the table is identical with the velocity of the bull pinion at the pitch circle, and as far as the speed of the table is concerned, the bull gear acts only as an idler gear. There are two factors that determine the size of the bull gear: First, it must be large enough so that the centers of all the other gears will be sufficiently low in the bed to make the teeth of these gears clear the under side of the table. Second, it must also be large enough so that the gear mounted on the same shaft as the bull pinion will clear the hub of the bull gear. The power that can be transmitted by the slowest running portion of the drive depends upon the strength of the bull pinion which, by reason of its small number of teeth, is weaker than the rack unless, as is frequently the case, the rack is made of cast iron and the pinion of steel. A common practice is to make all of the pinions steel forgings, the bull gear a steel casting, the other large gears of a high grade of cast iron or semi-steel, and the table rack of a high grade of cast iron. Forge, frog and switch, and other shops where heavy cuts are taken usually specify that all parts of the gear must be steel castings or steel forgings, and it is probable that in the near future all planers will be built in that way. The most satisfactory method to employ when these specifications are given is to make the table rack and the pinions steel forgings, and the large gears steel castings.

Determining the Proper Speed of the Table on the Cutting and Return Strokes

In designing a planer drive, the first thing to be considered is the cutting speed or speeds. In the case of a special machine, these may be determined by the customer. However, when a standard line of machines is being developed the best method is to so fix the ratio of the gearing that when a standard reversible planer motor is connected to the driving shaft, a fair average cutting speed will be obtained for ordinary work on iron castings. These motors usually run at from 250 to 500 revolutions per minute on the cutting stroke and from 500 to 1000 revolutions per minute on the return stroke. Thus, in order to obtain the average or standard cutting speed, the speed of the planer driving shaft should be about 375 revolutions per minute, which is a very good speed for a belt-driven machine. Just what the standard speed of the table should be depends upon the weight of the planer and the nature of the work for which the machine is designed. Planers used for taking light accurate cuts are run at higher speeds than heavy forge or frog and switch planers.

The general practice in the United States tends toward moderate speeds and heavy cuts, while in England light cuts and high speeds are favored. The English probably have the advantage of running their planers at a speed nearer the ideal for high-speed steels, and in addition consume less time on the return stroke, but there is great wear and tear upon the machine, due to the fast running and the excessive shock at the moment of table reversal. In order to reduce this shock, many English planers are equipped with spring buffers or shock absorbers which take up the momentum of the table at the instant of reversal. The American practice is less racking to the machine, and in spite of the slower speed used and the greater amount of time consumed in the return stroke, the amount of metal removed per hour is probably greater, due to the heavier cuts and the coarser feeds. Large planers are usually operated at slower speeds than small ones because of the greater weight of the moving parts. It should be understood, however, that the momentum is produced largely by the rotating parts, such as the gears, pulleys, and motor armature, and not by the table and its load.

Manufacturers of planers differ in their ideas concerning the correct average cutting speed for a planer of a given size, but in the opinion of the writer this should be as given in Table 1. These figures are intended for fairly heavy planers having but one speed and doing the usual class of work that is handled in a machine shop. It is necessary for the designer when planning a standard line of planers to establish standard speeds to be used on belt-driven machines.

As previously mentioned, the ratio of the total range of speeds on direct-connected reversible motors is 4 to 1, so that if a planer has a minimum cutting speed of 20 feet per minute, the maximum cutting speed will be 40 feet per minute, and the return speeds will range from 40 to 80 feet per minute. The cutting and return speeds may be varied through independent rheostats so that any cutting speed may be used in combination with any return speed. The cutting speed may be varied to suit the toughness of the material, and the return speed may be adapted to the load on the planer table. On planers of the open side type, there is more need for varying the return speed because the heavy overhanging loads that are frequently put on the table of these planers, are likely to cause a certain amount of whip if the table is reversed at high speed, and this results in a considerable strain on the machine. Therefore in designing belt-driven single-speed machines of this type it is well to make the return speeds somewhat less than those of standard planers.

Planers often Operated far below their Capacity

Many operators do not take nearly the size of cut that their planer has capacity for, and this is especially true in the case of planers of the open side type. It is astonishing to go into some shops and see the nibbling trifling cuts being taken on machines of the latest design. In fact a trip to a frog and switch shop would be a revelation to some shop men. Of course, frog and switch planers are usually run with little regard to the effect of the excessive strain on the accuracy of the machine. The average modern frog and switch planer of 36- or 42-inch capacity is about as heavy as the average 60- or 72-inch planer of standard design and consequently more rigid owing to its smaller span. The writer has seen a 36-inch frog and switch planer provided with a tool 3 inches square, having practically no cutting rake and very little clearance, cut a tough steel rail the full width of the head. This cut was 3 inches wide and 1/8 inch deep, and the chip was torn rather than cut from the work. The ammeter showed that the machine took about 105 horsepower; of course, no ordinary planer is capable of taking such a cut.

TABLE 1. AVERAGE CUTTING AND RETURN SPEEDS FOR VARIOUS SIZES OF PLANERS

Size of Planer, Inches	Cutting Speed, Feet per Minute	Return Speed, Feet per Minute
30 by 30	45	90
42 by 42	40	85
48 by 48	35	80
54 by 54	35	75
60 by 60	30	75
72 by 72	30	70

Machinery

The foremen of shops handling heavy work should ascertain the capacity of their planers to rough-finish castings or forgings having a large amount of metal to be removed. On heavy cast-iron work cuts 1/2 inch deep can frequently be safely increased to 1 1/4 inches deep with a feed of from 3/16 to 1/4 inch.

Dimensions of Planer Drives

The pitch of the table driving rack is the first problem to be solved when proportioning the gears of a planer drive. It has already been stated that the Lewis formula should not be used in figuring gears having a peripheral speed of 25 feet per minute or less, and so it becomes necessary to rely upon the experiences of various machine tool builders when determining the sizes of the rack. Table 2 gives the dimensions of racks for various sizes of planers. These dimensions do not agree exactly with some of those given in Tables 3 and 4, but represent a more ideal arrangement and are in slightly better progression. Such an ideal progression in sizes is generally only found where an entire line of machines is designed at the same time, and not always even then.

Tables 3 and 4 give the dimensions of the table drive gearing on machines that have been built and are performing work of the heaviest sort. A designer need not hesitate to adopt these proportions, as the machines have stood the test of time and service. Table 3 gives the dimensions for planers 42, 48, 54, and 60 inches in width, all of the gears being of the spur type. The dimensions given in Table 4 are for planers 72, 84, and 96 inches in width, the driving pinion and gear on these machines being of the herringbone type. It will be noted that in the illustration presented in connection with Table 4 the various mating gears are not shown in mesh. Nevertheless, the distances given between the centers of the various gears are the actual center distances.

TABLE 2. DIMENSIONS OF PLANER RACK TEETH

Size of Planer, Inches	Rack Dimensions, Inches		Size of Planer, Inches	Rack Dimensions, Inches	
	Circular Pitch	Width of Face		Circular Pitch	Width of Face
30	1	4 1/2	60	2	9
36	1 1/4	5	72	2 1/4	11
42	1 1/2	6	84	2 1/2	13
48	1 3/4	7	96	3	15

Machinery

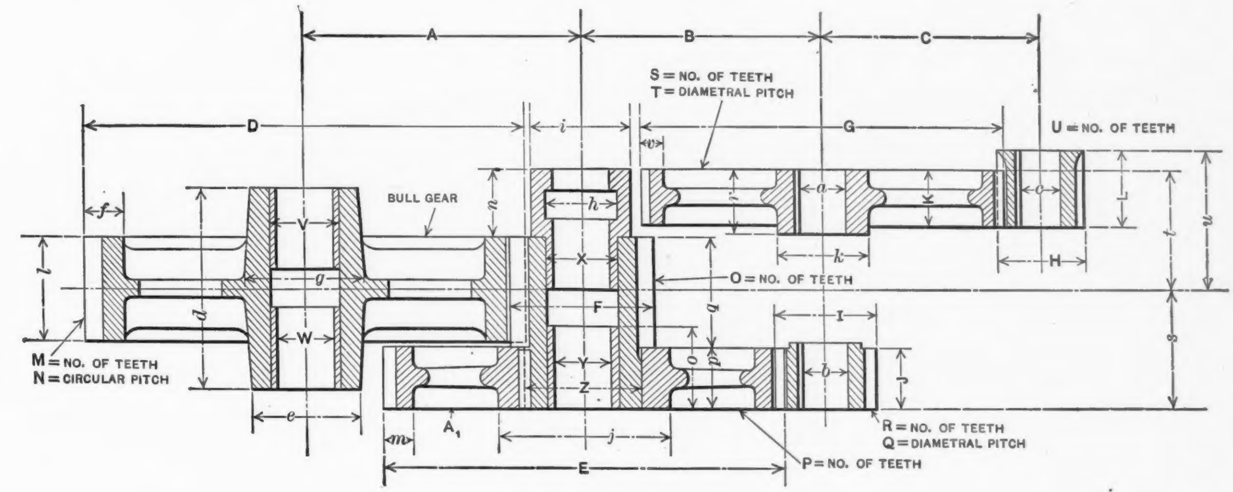
While the dimensions given in these tables are for machines rather heavier than the average, the trend is constantly toward heavier machines, and the designer who is developing a new line of planers will do well if he adheres to the sizes given.

Advantages of Using Same Gearing on Several Machines

For manufacturing reasons, it is often found desirable to use the same gearing on two or more sizes of planers. For example, it will be noticed that in the 48-, 54-, and 60-inch planers in Table 3, the respective gears all have the same pitch and number of teeth, but differ with respect to the width of the face. This system gives the same distances between the gear centers on all three of the machines and permits the use of the same jigs in boring the shaft holes in the planer beds. The 72-and 84-inch planers in Table 4 are provided with identical gearing. This gearing was originally designed for a very heavy frog and switch planer but was later applied to a 72-inch machine and finally was considered heavy enough for an 84-inch planer when a machine of that size was being developed. This is a question that must be decided by the individual shop. The reduction of the number of unlike parts on several machines undoubtedly lowers manufacturing costs.

The customer often feels that he is not getting a square deal when he purchases the larger of the two machines built on this principle, because he does not get a larger drive when paying for a larger machine. But if the drive is sufficiently large for the machine he is certainly not being cheated and he reaps the benefit of the decreased building cost in the decreased selling price. If a line of machines is built on this principle, it is more likely that repair parts will be on hand for less popular sizes of machines, which likewise benefits the customer. There is, of course, the argument that each part should be proportioned exactly according to its load so as not to be one pound heavier than necessary, but to offset this are the advantages already mentioned.

TABLE 3. DIMENSIONS OF TABLE DRIVE GEARING ON 42-, 48-, 54-, AND 60-INCH PLANERS



Planer Size, Inches	A	B	C	D	E	F	G	H	I
42	15.518	13.333	11.875	24.828	22.333	8.117	20	4.75	5.667
48	17.546	16.2	14.5	28.409	27.2	8.912	24.667	5.667	6.8
54	17.546	16.2	14.5	28.409	27.2	8.912	24.667	5.667	6.8
60	17.546	16.2	14.5	28.409	27.2	8.912	24.667	5.667	6.8

Planer Size, Inches	J	K	L	M	N	O	P	Q	R	S	T	U	V
42	3 3/8	3	4 1/8	50	1 1/2	15	65	3	15	78	4	17	3 15/16
48	4 1/2	4	6	49	1 3/4	14	66	2 1/2	15	72	3	15	4 1/2
54	6	5	7	49	1 3/4	14	66	2 1/2	15	72	3	15	4 1/2
60	6	5	7	49	1 3/4	14	66	2 1/2	15	72	3	15	4 1/2

Planer Size, Inches	W	X	Y	Z	a	b	c	d	e	f	g	h	i
42	3 3/16	3 15/16	3 3/16	6 1/2	2 9/16	2 7/16	2 3/16	11	6	2 1/4	6 3/4	4	5 1/2
48	3 3/4	4 1/2	3 3/4	7	3 1/16	2 15/16	2 7/16	14	6 3/4	2 5/8	7 1/2	4 1/2	6
54	3 3/4	4 1/2	3 3/4	7	3 1/16	2 15/16	2 7/16	18 3/4	6 3/4	2 5/8	7 1/2	4 1/2	6
60	3 3/4	4 1/2	3 3/4	7	3 1/16	2 15/16	2 7/16	18 3/4	6 3/4	2 5/8	7 1/2	4 1/2	6

Planer Size, Inches	j	k	l	m	n	o	p	q	r	s	t	u	v
42	9 1/2	5	5 3/4	1 5/8	3 5/8	4 1/2	3 3/8	6	3 1/2	6 1/2	6 1/2	7 5/8	1 1/8
48	10 1/2	6	7	1 7/8	5	5 3/4	4 1/2	7 1/4	5	8 1/4	8 1/2	10 1/2	1 5/8
54	10 1/2	6	8	1 7/8	6 1/8	7	6	8 3/4	5 3/4	10 3/4	10 1/8	12 1/8	1 5/8
60	10 1/2	6	9	1 7/8	6 1/8	7	6	9 1/4	5 3/4	10 3/4	10 5/8	12 5/8	1 5/8

Machinery

Designing the Bull Pinion of a Planer Drive

In order to illustrate the methods to be followed in designing the driving gears of a planer, assume that it is desired to design these gears for a 42-inch machine. By referring to Table 2, the circular pitch of the rack on a 42-inch planer will be found to be 1 1/2 inches. Next assume that it has been determined that the bull pinion shaft should not be less than 3 3/16 inches in diameter, and as the pinion runs loose on this shaft, the outside diameter of the pinion bushing should be about 3 15/16 inches. If these dimensions are laid out to scale, it will be found that the bull pinion should not have less than 15 teeth in order to have a thickness of metal between the bottom of the teeth and the bore, about equal to the depth of the teeth. Thus if the bull pinion has 15 teeth of 1 1/2 inch circular pitch, the pitch circumference will be 22 1/2 inches, and consequently for every revolution of the bull pinion the platen will move 22 1/2 inches. By referring to Table 1, it will be found that the average cutting speed of a 42-inch planer is 40 feet per minute, and from this the total ratio of the gearing must be determined. Suppose that the planer should have cutting speeds of from 24 to 48 feet per minute when driven by a direct-connected reversible motor. If the motor runs at from 250 to 500 revolutions per minute on the cutting stroke, the speed of the pulley shaft of a belt-driven machine can be found by the following proportion: $A : B :: C : D$, in which A equals the minimum cutting speed of the planer table in feet per minute; B equals the minimum number of revolutions per minute of the motor; C equals the average cutting speed of the planer in feet per minute; and D equals the number of revolutions per minute of the driving pulley on a belt-driven machine.

Substituting in the proportion, the values given in the example, we have:

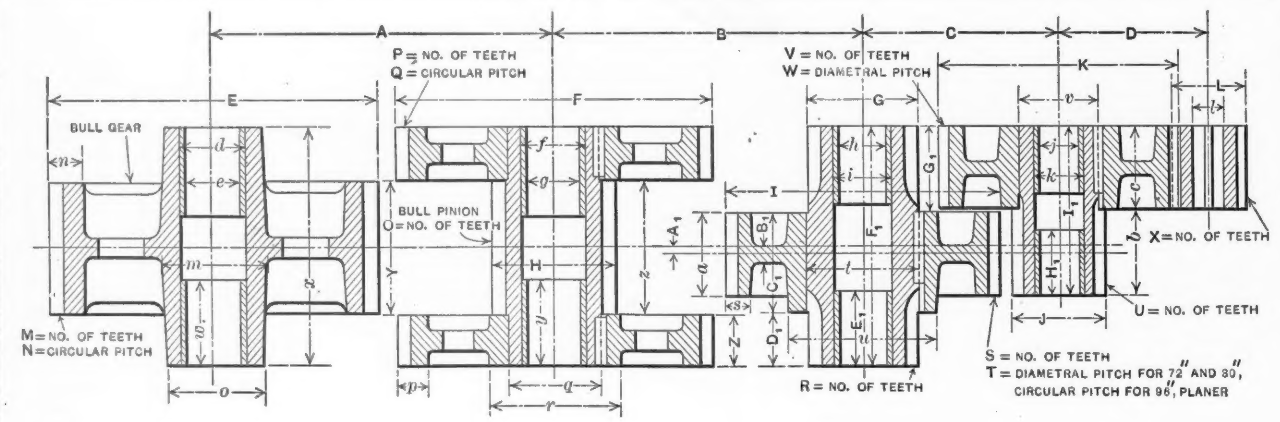
$$24 : 250 :: 40 : D$$

and

$$D = 416 \text{ revolutions per minute}$$

As the table will move 22 1/2 inches or 1.87 feet per revolution of the bull pinion, the necessary revolutions per minute of the bull pinion can be determined by dividing the average cutting speed of the table per minute by the distance that the table is moved in one revolution of the bull pinion. Thus, $40 \div 1.87 = 21.4$ revolutions per minute, the speed of the bull pinion. After the number of revolutions per minute of the bull pinion has been ascertained, the ratio of the entire

TABLE 4. DIMENSIONS OF TABLE DRIVE GEARING ON 72-, 84-, AND 96-INCH PLANERS



Planer Size, Inches	A	B	C	D	E	F	G	H
72	19.735	18.383	15.75	13.333	30.558	28.966	10.027	11.459
84	19.735	18.383	15.75	13.333	30.558	28.966	10.027	11.459
96	24.351	22.599	18.104	15.4	37.242	36.923	10.822	15.279

Planer Size, Inches	I	J	K	L	M	N	O	P	Q
72	25	8.5	21.2	6.534	46	2	16	50	1¾
84	25	8.5	21.2	6.534	46	2	16	50	1¾
96	28.966	9.469	25.040	7.040	37	3	14	56	2

Planer Size, Inches	R	S	T	U	V	W	X	Y	Z	a	b
72	16	48	2	15	62	3	18	12	4¾	7½	7¾
84	16	48	2	15	62	3	18	12	4¾	7½	7¾
96	15	50	1¾	15	61	2½	16	14	5½	9½	10¾

Planer Size, Inches	c	d	e	f	g	h	i	j	k	l	m
72	7½	6	5¼	6	5¼	4¾	5¼	3 15/16	4 7/16	2 15/16	10
84	7½	6	5¼	6	5¼	4¾	5¼	3 15/16	4 7/16	2 15/16	10
96	7½	7¼	6¼	7¼	6¼	4¾	5½	4½	5	3 7/16	11½

Planer Size, Inches	n	o	p	q	r	s	t	u	v	w	x
72	2⅞	9	2⅝	8½	12	2¼	10¼	13½	7¼	8	21¾
84	2⅞	9	2⅝	8½	12	2¼	10¼	13½	7¼	8	21¾
96	4	11½	3	11	17	2¾	11	17	9¼	8¾	27

Planer Size, Inches	y	z	A_1	B_1	C_1	D_1	E_1	F_1	G_1	H_1	I_1
72	8	12¼	⅝	1½	9	5	7	21¾	7¾	6	15¼
84	8	12¼	⅝	1½	9	5	7	21¾	7¾	6	15¼
96	8¾	16	0	2	9½	8¾	8¾	27	8¾	6	18¼

Machinery

gearing can be found by dividing the revolutions per minute of the driving shaft by the revolutions per minute of the bull pinion. Thus $416 \div 21.4 = 19.4$, or the ratio of the entire gearing. If the drive is to be of the same design as that shown in the illustration in Table 3, the next step is to divide the ratio between the two pairs of gears connecting the bull pinion shaft with the driving shaft.

Designing the Reduction Gears and Driving Pinion of a Planer Drive

If the bull gear is drawn to scale in mesh with the bull pinion, it will be found that the largest gear which can be put on the hub of the bull pinion cannot be much larger than 22 inches in pitch diameter or about 67 inches in pitch circumference. If the gear is larger than this, it will interfere with the hub of the bull gear. As 67 inches equals 5.6 feet, the velocity of a gear of this size at the pitch circle would be equal to $5.6 \times 21.4 = 119.8$ feet per minute. The ratio between the peripheral speed of this gear and that of the bull pinion is as 120 : 40 or as 3 : 1. Therefore, the teeth on gear A_1 in the illustration shown in Table 3 need only be one-third as strong as those of the bull pinion. This table gives the face width of the bull gear on a 42-inch planer as 5¾ inches, and that of gear A_1 as 3⅜ inches. The circular pitch of gear A_1 can then be found from the following equation:

$$P = \frac{A \times B}{C \times D}$$

in which

A = circular pitch of the bull pinion in inches;
B = width of the bull pinion face in inches;
C = width of face of gear A_1, in inches;
D = ratio between the peripheral speeds of the two gears;
P = circular pitch of gear A_1 in inches.

Thus

$$P = \frac{1.5 \times 5.75}{3.375 \times 3} = 0.85 \text{ inch}$$

Therefore, a gear of 3 diametral pitch will be amply large. A gear of this pitch, 22 inches in diameter, would have 66 teeth, but as gear A_1 on the planer of which the dimensions are given in Table 3, had 65 teeth, assume that a gear of this size is to be used.

The next step is to see how small a pinion can be meshed with this gear. If the diameter of the shaft on which the pinion is to be placed is 2 7/16 inches in diameter, as given for the 42-inch planer in Table 3, and due allowance is made for the key, a pinion having at least 15 teeth must be used. The ratio between gear A_1 and its pinion is then as 65 : 15 or as 4.33 : 1. It is now only necessary to find the ratio of the driving pinion and its mating gear.

It was previously determined that the ratio of the total gearing is as 19.4 : 1, and as the ratio between gear A_1 and its pinion is as 4.33 : 1, the ratio between gear B_1 and the driving pinion must be equal to 19.4 ÷ 4.3 = 4.5. If a layout has been developed to this point, it will be found that the largest gear that will clear the oil-cellared bushing that projects from the bull pinion will be 20½ inches outside diameter. The pitch of the driving pinion, then, should be about 4 diametral pitch. A gear of this diametral pitch having 80 teeth would have a pitch diameter of 20 inches and an outside diameter of 20½ inches. Assume that a gear having 78 teeth is selected; then in order to find the number of teeth in the driving pinion, divide the number of teeth in gear B_1 by the ratio between this gear and the pinion or 78 ÷ 4.5 = 17.3. The driving pinion will therefore have 17 teeth.

In order to calculate the actual cutting speed of the table in feet per minute obtained with this gearing, it is only necessary to multiply the speed of the driving shaft in revolutions per minute by the ratios of the two sets of reduction gears and by the velocity of the bull pinion at the pitch circle in feet per minute. Thus

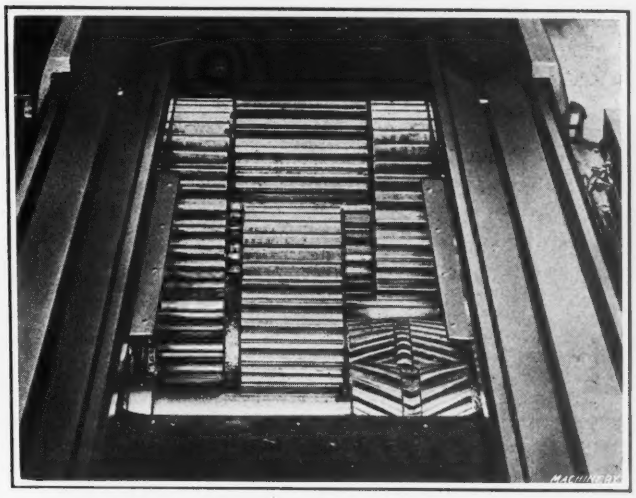
$$\frac{416 \times 17 \times 15 \times 1.87}{78 \times 65} = 39.1 \text{ feet per minute}$$

Distinguishing Features of Various Planers

The proper relation between the cutting and return speeds is obtained by means of the driving pulley ratios. It is not the purpose to deal with this phase of the subject in this article. However, it is not out of place to warn the designer of two things: First, that the belt speeds should not greatly exceed 3000 feet per minute, as speeds in excess of this burn the belt because of the sudden reversal and consequent slippage. Second, that belts over 6 inches in width cannot be successfully shifted on a planer, so that where a 6-inch belt is inadequate, a four-belt drive should be employed, using two belts to produce the forward motion of the table and two for the return motion. The only alternative for this is a device employed some years ago by a leading planer builder, whereby the belts were alternately tightened and slackened by means of a pneumatically operated idler pulley.

The preceding methods may also be followed in designing any of the gear trains for the planers given in Table 4, the principle being the same. The chief differences between the heavier and lighter machines are that in the former herringbone gears are used in the first reduction; an additional pair of gears is necessary in order to obtain the desired reduction without making the gears excessively large; and, two pairs of gears are used in the last reduction in order to keep the gearing within the limits of the width of the planer bed. A little calculation will show that it is not only the slower speeds of the heavy planers that necessitate the increased reduction, but also the greater pitch circumference of the bull pinion due both to the larger shaft and the greater pitch required. The halftone illustration shows this type of drive on a very heavy frog and switch planer.

This particular machine is equipped with a unique oiling system. The metal of the bed extends under the gearing and forms an oil reservoir into which the larger gears dip, thus oiling the gear teeth and table rack as they rotate. This reservoir is connected to a smaller auxiliary settling tank, from which the oil is pumped, by means of a small electrically driven pump, through a strainer to the gear bearings and ways of the machine. The overflow from the bearings returns directly into the large tank, while the drippings from the rack and table ways are caught in extended pans at the end of the bed. These pans are fitted with felt wipers and coarse strainers, and the oil is returned by gravity through large pipes to the tanks. Each bearing and way has an independent stop-cock to regulate the flow of the lubricant as well as a pet-cock to serve as a telltale. In this way a constant oil circulation is kept up.



Driving Gears employed on a Heavy Frog and Switch Planer

* * *

FOREIGN CREDIT INSURANCE

Announcement has been made of the organization of a mutual company for the insurance of credits in foreign countries. The new company is to be known as the American Manufacturers' Foreign Credit Insurance Exchange. The purpose of this mutual exchange will be to supply that element in foreign trade that has heretofore been lacking—adequate information on the financial status of foreign merchants and a reasonable safeguard in individual business transactions. Being a company organized on reciprocal lines the insurance will be written at net cost, and not for profit. The organization of the American Manufacturers' Foreign Credit Insurance Exchange is the result of several years' search for ways and means to solve the problem of foreign credits. At the annual meeting of the Foreign Trade Council at Cincinnati three years ago, George R. Meyercord, first vice-president of the Illinois Manufacturers' Association, and president of the American Manufacturers' Foreign Credit Underwriters, presented a rough plan for the insurance of foreign credits. Since then the foreign trade committee of the Illinois Manufacturers' Association has been working on a flexible and effective plan to provide such a service to the American manufacturer. The result is that there has been formed by officials of the Illinois Manufacturers' Association, and with its approval and endorsement, the American Manufacturers' Foreign Credit Insurance Exchange, Chamber of Commerce Building, Chicago, Ill.

* * *

According to a report issued by the United States Bureau of Mines experiments conducted at Columbus, Ohio, by the use of 450 crucibles show that there are thirteen varieties of clay in the United States that are better bond clays for steel melting crucibles and two that are better for brass melting crucibles than Klingenberg clay formerly imported from Germany and believed to be indispensable.

Production Milling of Group Parts

Production Rates Obtained and Standard Fixtures Employed for Machining Groups of Parts of Similar Design by Straddle-milling

By GEORGE M. MEYNCKE, Sales Manager and Mechanical Engineer, Oesterlein Machine Co., Cincinnati, Ohio

THROUGH the joint activities of the Society of Automotive Engineers and the manufacturers of drop-forgings, a complete standardization of proportions has resulted in the design of automobile yokes, forks, and clevises. With few exceptions, these parts are drop-forgings, although in the tractor field malleable castings are frequently used. Enormous quantities of these fork-shaped parts are employed in the construction of automobiles, trucks, and tractors. A common application for the larger forgings of this general design is in the universal joint of an automobile. The most common example of the use of the medium-sized forging is in the tie-rod yokes that connect the front wheels of an automobile. The smaller forks are known as clevises, and range in size from those used on brake rods to the very small forks that are employed in the lever systems of carburetor and magneto control.

A good idea of the quantity of these parts regularly used may be gained from a report made by the sales promotion department of a machine tool manufacturer, which states that for pleasure cars alone the production schedule for 1920 calls for an output in the neighborhood of 80,000,000 forks, yokes, and clevises. This manufacturer builds a milling machine that is especially suitable for this class of work, so that an exhaustive study was given this particular group of forgings with the view of developing a fixture that would be of standard construction, with the exception of the holding jaws. These, of course, must be made to suit the particular size and shape of the forked forging being machined.

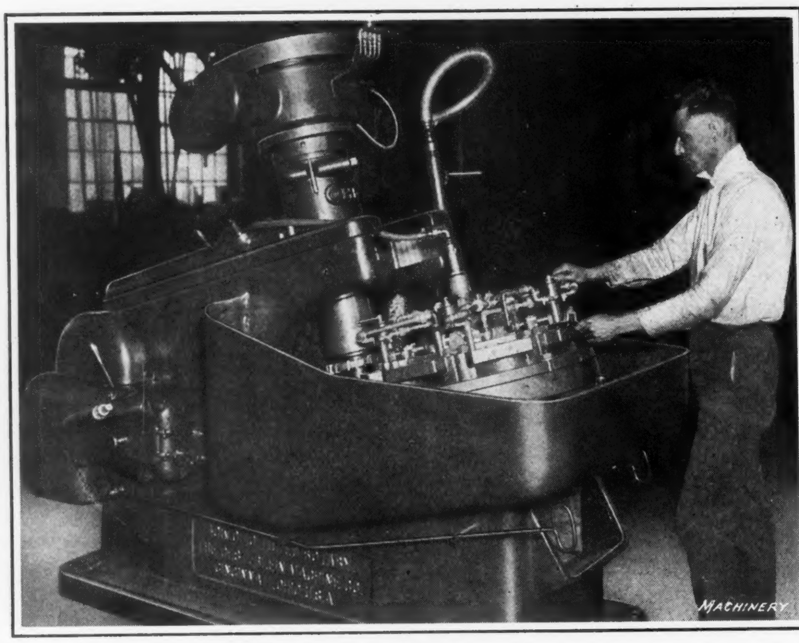


Fig. 1. Ohio Tilted Rotary Milling Machine equipped with Fixtures for straddle-milling Yokes

It appeared that by making the fixture a manufacturing rather than a tool-room proposition, a fixture would be developed which would be more highly efficient than the ordinary class of special fixtures. The fixture problem was complicated by the fact that some clevises are comparatively small, especially for handling on the type of machine produced by this machine tool concern. In other words, the operation of the machine is such that in order to work at full capacity, rapid handling of the parts is essential. As a means to this end, the application of compressed air for clamping purposes was adopted.

The type of machine on which it was planned to do the work was the Ohio tilted rotary milling machine, built by the Oesterlein Machine Co., which is shown in Fig. 1. This machine may be used as a continuous or as a station miller. For yoke, fork, and clevise milling, the station method is used—that is, there is a loading position for the operator from which the work-table indexes rapidly like a turret, and in due time arrives at the cutter position. During each indexing operation, the milling cutter is withdrawn radially and is automatically fed into the work as soon as the next automatic index motion has been completed. It was found that a higher output was obtainable when the machine was rigged up for station milling, using a quick indexing and a lower rate of feed, than could be obtained by continuous milling. It was also shown that only four work-holding stations were required to obtain an output greater than was possible with continuous milling. The type of fixture employed for the station method of milling is illustrated in Fig. 2, which also shows a tie-rod yoke in the work-holding jaws.

The operation of the machine is automatic, the operator's work consisting only of loading and unloading the fixtures. As previously stated, the cutters feed radially into the work, being carried in a reciprocating ram. The feed-cam *C*, Fig. 3, controls the traverse of the cutter, and is made to function as a double cam, thus providing positive return for the ram. The contour of the cam is designed to provide a quick return, a dwell while the table indexes to the next station, and a slow feeding rate. There may be one feed-cam for a group of parts, or it may be advantageous to have a cam for each sized part. If one feed-cam is used, the travel must be sufficient to mill the longest piece. The output and the rate of feed is the same for all parts on which the cam is used. By using a cam for each part, a finer feed for a given output is often obtainable, or a higher output may be secured at a given rate of feed. The function of the index cam *B* is to hold the table indexing mechanism in operation while the table is being indexed from one station to the next which, of course, in the present case is 90 degrees. At *D* in this illustration is shown the arbor and cutter gang in relation to the tie-rod yoke which it straddle-mills.

The design of the removable jaws may be seen at *A*. These jaws vary for each size or shape of yoke, the pair shown being die-sunk to accommodate the shape of the yokes. Smaller yokes are held two for each jaw, or "two-story" as it is called which, of course, requires twice as many cutters on the arbor. On clevises, the jaws are made with a central hinge in addition to being two-story high. These jaws hold four parts at each station. The production rate obtained when the fixture is equipped with jaws for holding one forging is 240 per hour; when using the two-story jaw, the rate is double, or 480 per hour; when four parts are held at a

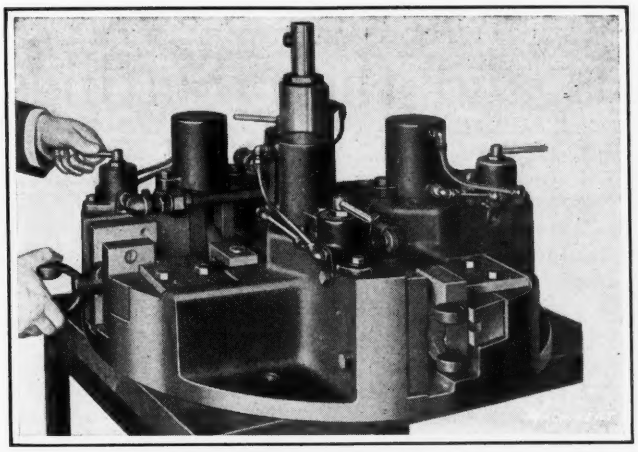


Fig. 2. Type of Fixture used for milling a Group or "Family" of Fork-shaped Automobile Parts

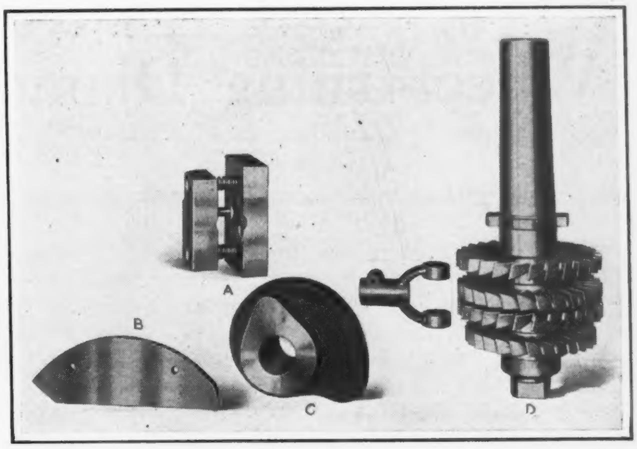


Fig. 3. (A) Jaws used on Special Fixtures. (B) and (C) Index and Feed-cams used on Machine. (D) Cutters mounted on Arbor

time at each station the output is 960 parts per hour. A higher degree of finish is obtained on the smaller yokes than on the large ones that are held one at each station, for since the timing is identical in both cases, (fifteen seconds per station) the feed is slower and the cam travel is much less.

Representative types of these forgings are shown in Figs. 4 and 5, which give an idea of some of the varieties encountered in this group or "family" of forgings. Those parts in the upper section of Fig. 4 are of the type held in the fixture singly; the four forgings at the left in the lower section are held two at each station, while the four remaining parts are held four at each station. Referring to Fig. 5, three groups of parts may be seen which are also applicable to the standard fixture, but require special jaws for each part. Of the four forgings shown in the lower left-hand corner of the illustration, the two smaller parts are rod ends and are produced at the rate of 960 per hour. The five parts shown in the right-hand side of the illustration are brake adjusting rods, the four parts in the upper left-hand corner are brake levers, and the two forgings in the lower left-hand corner are rod ends, all of which are produced at the rate of 480 per hour.

As previously stated, the jaws are pneumatically operated, the compressed air being piped to the air distributor at the center of the table, then through this distributor to the air valves, one of which is located at each operating station. Suitable pipe connections carry the air from the air valves to the cylinders in such a manner that when the piston is raised the work is released, and when it is lowered the work is clamped securely in position. The operation of the jaws is controlled by manipulating the air valve as shown in Fig. 2. An air pressure of 80 pounds per square inch is employed, and in connection with a system of multiplying levers, this produces the pressure necessary to hold the work rigidly.

GOVERNMENT BUREAUS AND FOREIGN COMMERCE

In view of the proposal to materially reduce the appropriation for the Bureau of Domestic and Foreign Commerce, the reasons why such a proposition was made should be placed on record. Inquiry from the Congressional Committee having this matter in hand indicates that it was not the intention to interfere with the facilities for the extension of foreign trade, but it was the desire of the committee to bring to the attention of Congress and the public the present waste of money resulting from duplication of effort.

The State Department has more than four hundred consular agents besides many special agents engaged in promoting our foreign trade. More than three-fourths of the commercial information received in this country comes through that source, sifted first through the State Department and then given to the Department of Commerce for the use of the public. The Department of Commerce, in its attempt to extend our foreign trade, has been sending its agents to the places where we already have consular agents. There is constant friction between these representatives, each contending that he is the one who should have entire supervision of the work immediately at hand, and the object of the Congressional Committee was to provide means whereby this work would be placed either all in the hands of the State Department or all in the hands of the Bureau of Foreign and Domestic Commerce.

Representatives of the State Department as well as representatives of the Department of Commerce examined by the Congressional Committee confirmed these facts in reference to duplication of effort, and agreed as to the necessity of unification of responsibility in one department or the other, but each contended that his department should be chosen.

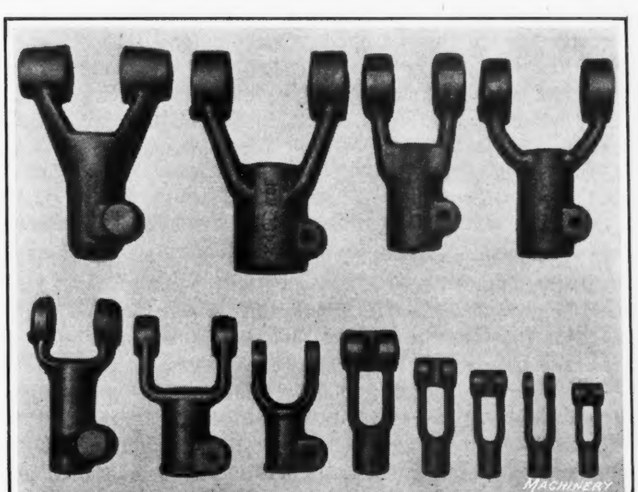


Fig. 4. Collection of Yokes, Forks, etc., of Various Sizes and Styles, machined on the Tilted Rotary Milling Machine

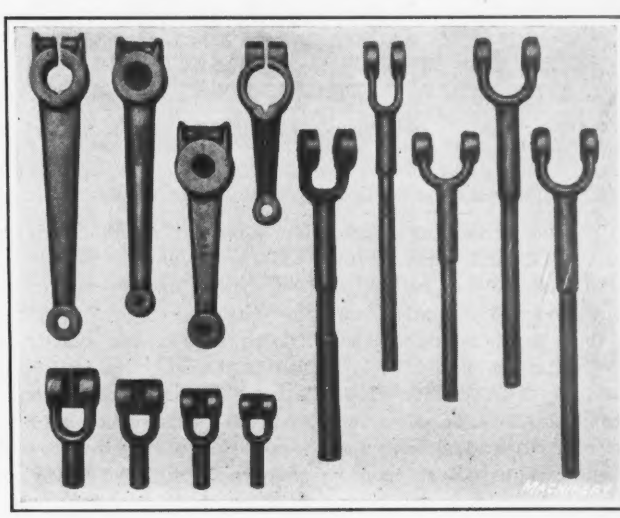


Fig. 5. Another Group of Forgings of the Yoke Type, such as may be handled conveniently by the Equipment shown in Fig. 2

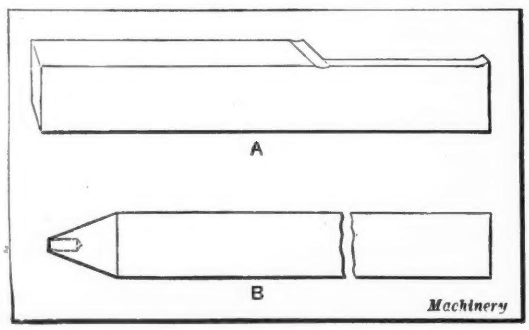
Wheel-truing Diamonds and their Settings

By EMIL GOOD

THERE are five different kinds of diamonds employed for truing grinding wheels, namely, Jaegers-Fontin, Ballas, black carbon, brown bort, and gray bort. The Jaegers-Fontin diamond is very hard and is the most brittle of all species. It is grayish in color, irregular in shape, and possesses a very coarse grain. It fractures easily, usually at the wearing point, which chips off in little pieces. It may be set firmly without difficulty on account of its rough surface, but it is in disfavor by the men using it, the claim being made that the wheel cannot be satisfactorily dressed on account of the rough surface of the stone. In addition to these disadvantages, it is also very expensive.

The Ballas type of diamond is a clear white stone, hard and brittle, but not to the same degree as the Jaegers-Fontin type. It is of a finer grain than the latter and generally gives more satisfactory results. The black diamond is soft but tough. It does not break but wears too quickly to be suitable for the purpose of truing grinding wheels. It is also very expensive.

Of the bort types, the brown stone has a smooth surface and a fine grain, and is transparent. It is not as hard, however, as either the Jaegers-Fontin or the Ballas types, but it is very tough. The color of the stone is produced by the presence of iron oxide. The gray stone is much the same as the brown stone except for the color and for the fact that it is a little harder and more brittle. Neither of these stones is very expensive; therefore, since diamonds are easily ruined, the loss of a brown or gray bort does not mean as much from an economical point of view as does the loss of any of the other three grades. The bort stones are sufficiently hard to withstand all reasonable wear, and their shape is such as to permit them to be securely set.



Diamond-holder and Combination Lathe Tool used in manufacturing it

The shape of the wheel-truing diamond is an important factor in determining its value, the ideal shape being an eight-sided stone. The diameter and face of the grinding wheel, its hardness, and the type of abrasive used are factors which should be considered when determining the proper size of stone to use. A diamond should never be used on a grinding wheel which is mounted on a loose spindle, as the tendency will be to shatter the diamond and probably to pulverize it. The diamond should never be rammed into the grinding wheel, and should not be traversed across the face of the wheel too quickly. It is important to note that a stream of water should always be used during the truing-up operation.

Making the Holder and Setting the Diamond

The accompanying illustration shows at *A* a combination cutting-off and taper-turning tool by means of which the manufacture of a suitable holder can be greatly facilitated. The holder *B* is made from cold-rolled bar stock, ½, ⅝, and ¾ inch in diameter, which is first squared on the end by the tool, after which a hole is drilled in the end, the drill being held in the tailstock of the lathe. The size and depth of this hole depends, of course, upon the size of the diamond to be used and should not be less than ⅛ inch or rarely greater than ¼ inch in diameter. In drilling this hole, the proper depth may be indicated by marking the drill, so as to obtain an even depth for all holders of the same size. The drill is next removed and the special tool *A* employed to form the taper on the nose of the holder. The angle of the taper-turning tool should be such as to produce an included angle of 35 degrees on the end of the holder. The tapered end should produce a sharp edge around the hole. The holder is finally cut off by the use of the same tool, the usual length being about 8 to 11½ inches. The angle of the taper is important, because if the taper is less than 35 degrees, the prongs which are later formed will be too weak and will spring, so that difficulty will be experienced in securing the diamonds in place. On the other hand, if the taper is as great as 45 degrees, the setting will be clumsy and so unyielding that the diamond setter is likely to deal the prongs such a severe blow with his hammer that a broken diamond may result.

After the taper has been turned and the hole drilled to the proper depth, this end of the holder is slit into quarters, the saw being run in to the same depth as that of the hole. This prevents any air pockets being formed during the operation of brazing, and also produces four prongs, similar to the setting of a ring. Next give the prongs a little clearance by running the corner of a mill file along the passageway of the saw cut on the tapered part of the holder, and then remove the knife-edge on the end by brushing it lightly with the file so as to produce a flat surface on the top.

Flaws and marks should be so placed that they are perpendicular in the setting. In sorting diamonds for their respective holders, the best point of the diamond is turned up, in which position it is held by the thumbnail of the left hand; then using an 8-ounce hammer, gripped short, the first prong is hammered down with a blow or two. The next prong to be hammered down is the one located diametrically opposite to the first one, and during this operation the diamond is still held by means of the thumbnail, after which the two remaining prongs are similarly hammered down. If the hole is of the correct depth and the diamond is properly set, the diamond will project somewhat from the setting. The prongs should then be worked down to the stone by using a punch which may be made from an old rat-tail file. In performing this operation, care should be exercised to see that the hammer blows are not delivered directly toward the diamond. The diamond is not securely set when the prongs enclose the stone. It should be held about its equator and not at the pole, as the latter is exposed when in use. It is of paramount importance that the diamond be set securely before it is brazed, as otherwise too much reliance is placed on the braze.

Brazing the Setting—Final Operations

In order to secure a firm setting for the diamond, it should be clamped securely in position by the prongs. These exercise a certain amount of pressure or tension, and if they lose this tension the diamond setting is then dependent on the brazing only. The best flux to use when brazing consists of equal parts of borax and boracic acid. An enameled pan should be filled one-third full with this mixture and the remainder filled with water. This liquid should be boiled until the powdered ingredients are dissolved, and then used to dip the setting in, prior to performing the brazing operation. In case the fluid is used more than once, it should be boiled each time before using. A tin can of powdered borax

and boracic acid should also be provided for tipping the brazing wire when depositing the spelter. In brazing, it is well to remember that the spelter will flow toward the locality where the greatest amount of heat is applied and that this metal will remain there. When applying the heat, using a neutral acetylene flame, the cone should be directed at least one-half inch below the taper of the setting; the expansion of the holder takes place at this point first and not at the setting, and as the brazing is done in a yise the flame is played all around the holder, so that it will become uniformly heated to a white heat. The brazing wire which is first heated, is then tipped in the powdered flux, and the spelter applied directly over the diamond point. As the wire melts, the spelter will be melted by the excessive heat below the taper of the holder and will flow into the hole under the diamond, surrounding it and filling the setting completely. After withdrawing the flame and allowing the holder to cool slightly, the diamond itself should be completely covered with spelter. Another advantage in applying the heat below the setting is that the prongs do not become overheated, and are thus kept in tension, obviating all possibility of the diamond becoming loose from the application of heat. It will be found if two diamonds are secured in their respective holders by means of the prongs, that if one is heated over the setting and the other somewhat below the taper and allowed to cool without brazing, the first will become loose, while the other will remain as firm as when first set.

Provided the diamond has been set according to the method described, no looseness will be found to exist. The diamond is then taken to a grinding wheel and the point of the diamond exposed by grinding the top. The coating of spelter on the taper is then turned off in a lathe, after which the diamond is freed from the metal to a distance of about 1/32 inch from the point, and then polished.

Diamonds that become loose in the setting or that become chipped can be reclaimed by either cutting or burning them out. Each stone should be tested for the purpose of detecting imperfections, and a test of the strength of the setting should be made by using a pair of tweezers in attempting to loosen the stone.

Among the other methods of setting diamonds may be mentioned the one in which the stone is set in copper and also the setting in which monel metal is used. In the latter case, the diamonds are either put in a casting or else the metal is poured into a mold, holding the diamond in a fine nickel screen. This method is extensively used, but it is quite complicated and not especially satisfactory. Good results can also be obtained by the peening method, but when this practice is followed the work should be done by an expert. Objections have been raised to the method here described, but in cases where it has been actually put to the test, it has given excellent results.

* * *

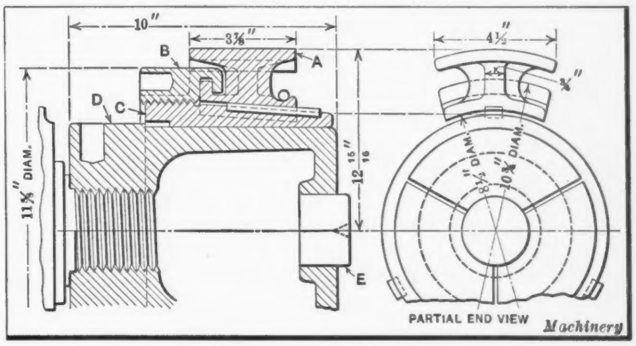
The larger portion of the steel-making pig iron is transported in molten condition from the blast furnace to the steel mill and is never marketed in the form of pig iron at all. Similarly, during the initial stages of rolling steel products, the ingots, blooms, and slabs are merely intermediate stages in the production of steel and not ordinarily commercial products. Thus, before the ingot has lost the heat acquired in producing the steel itself, it has been rolled into a bloom, a slab, or a billet and is ready to be rolled into some finished rolled product, such as rails, plates, or structural shapes. This saving of heat and the use of automatic machinery in handling these heavy rolled products keep down the fuel and labor costs; therefore, the prices of the heavy products are largely controlled by the cost of the crude steel. But in the case of light-rolled products, such as wire rods and sheets, more rolling is required, with a corresponding loss of heat and greater use of hand labor; therefore, the prices of light-rolled products are largely influenced by the fuel and labor costs.

EXPANSION MANDREL FOR INSIDE CHUCKING

By J. E. UNGER

The expansion mandrel illustrated represents a type of chucking device which has been in constant service for fifteen years on commutator work. For this particular kind of work, it has proved of great value, although its usefulness is not limited to commutator work alone, but may include any work of a similar type, and with proper modifications may be adapted to a large variety of work. The design of the mandrel is such that the parts can be rapidly chucked, and there is also a provision whereby the work may be removed and reversed, that is, it may be turned end for end, without releasing the grip or without disturbing its position. The work to be machined is placed over the shoes *A*, of which there are three located 120 degrees apart on the tapered cylinder *C*.

The circumferential location of each shoe is maintained by means of a key, and their longitudinal position is adjusted by means of a special nut *B*, which is designed to lock over a flange on each of the shoes, as the illustration clearly shows. A special wrench is employed to operate nut *B*, by means of which the shoes carrying the work are drawn up so as to lock the nut and the three shoes together. The taper plug *E* is then driven into the center hole of the cast-iron hub *D* which is slit, as shown by the end view. A light



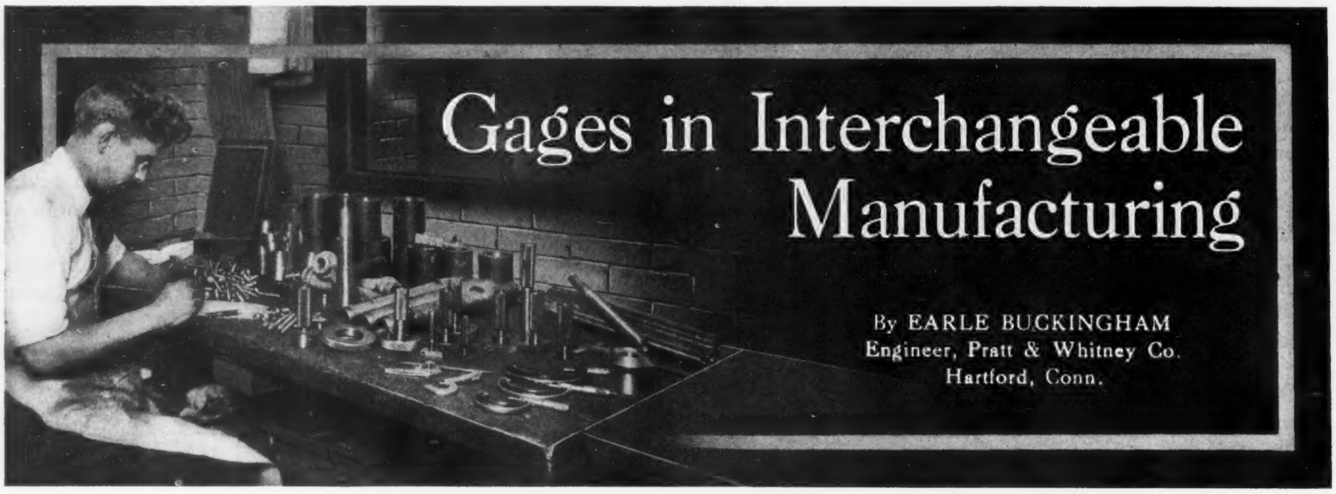
Internal Chucking Device originally designed for Commutator Work

blow only is required to expand this split hub sufficiently to bind the cylinder *C* securely to the hub. When the work is reversed, a ram rod extending through the lathe spindle is employed to knock out plug *E*, after which cylinder *C*, carrying the clamping members of the device and the work, may be readily slipped off and turned end for end. The clearance between the hub and the cylinder is about 0.002 inch. Ordinarily the amount of expansion is from 3/16 to ¼ inch.

Commutators having segments from 4 to 16 inches in length are regularly held on this expansion mandrel while being machined, although there is nothing to prevent the use of extensions for hub *D* and the shoes *A* to suit the dimensions of the work to be machined. Extra extension pieces curved to suit the shape of the shoes may be bolted to them if it is desired to adapt the chucking device to work having larger bore diameters than those ordinarily handled. The inside diameter of arch-bound commutators is not trued up or bored, and for such work this mandrel has proved of great advantage in rapidly centralizing the work when turning it in the lathe. It is also profitable, in case of work which is likely to spring, to employ a greater number of shoes than three so as to overcome this tendency.

* * *

The magnitude of France's reconstruction work is partially indicated by some of the figures given out by the French government which show that about 100,000 houses must be entirely rebuilt, and the building work alone will require the labor of 700,000 people for one year. The reconstruction of the highways and railways will require the labor of 15,000 men for one year.



Gages in Interchangeable Manufacturing

By EARLE BUCKINGHAM
Engineer, Pratt & Whitney Co.
Hartford, Conn.

First of Two Articles Describing Various Types of Gages and Gaging Devices Employed in Manufacturing Interchangeable Parts

A GAGE is an instrument or apparatus for measuring a specific dimension. Every manufactured part is measured during its production and after its completion in one way or another. This applies equally to a single piece made for a special machine or as a repair part, or to a hundred thousand duplicate parts manufactured for an interchangeable product. The mere removing or shaping of the raw material in itself is seldom a difficult or exacting task. The critical point is in stopping this process at the proper moment. The approach to this point can be watched only by some form of measurement. The most elementary method of measuring a part is to try it with the companion parts with which it is to operate. Such was common practice in the early stages of mechanical industry. This practice necessarily continues to a great extent with repair work and also in the construction of small numbers of special machines, jigs, and fixtures.

A later method consisted of measuring the parts individually, with standard measuring tools such as scales, calipers, verniers, and micrometers. In many cases, these measurements were merely preliminary to the fitting together of the parts at assembly. Fitting at assembly is expensive. It takes time and requires a relatively large amount of space and highly skilled labor. Most of the metal removed at this time is done by hand. If any great amount of metal is to be removed, the part must be taken back to the machine shop and relocated on the machine thus interrupting other work. Under such conditions, the economic production of any great quantities of duplicate mechanisms is impossible.

Necessity of Gages in Economical Interchangeable Manufacturing

Interchangeable manufacturing was developed primarily to eliminate these conditions. If parts could be made close enough to some uniform size so that most, at least, of this fitting could be eliminated, it was evident that larger production could be secured with the expenditure of the same effort. Furthermore, many parts could be machined in advance and carried in stock, thus making earlier deliveries possible in many cases. Clearly, one of the most essential factors of such a plan is a reliable means of measuring each part as it is made. This measuring, to be effective, must insure uniformity and be economical. The use of standard measuring instruments such as micrometers is not always reliable in measuring large numbers of duplicate parts. In the first place, for many exacting conditions, measurements hurriedly made by several different men do not prove sufficiently uniform. In the second place, many of the surfaces to be measured are not readily accessible by standard measuring tools. And, in the third place, while both of the preceding conditions may often be satisfactorily met, the time consumed by this method would be too great to be economical.

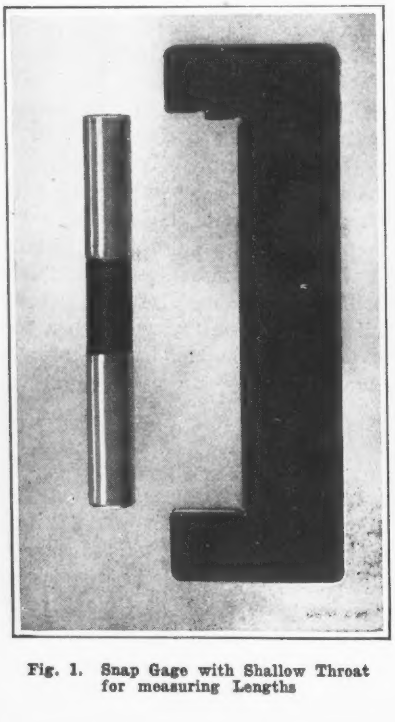


Fig. 1. Snap Gage with Shallow Throat for measuring Lengths

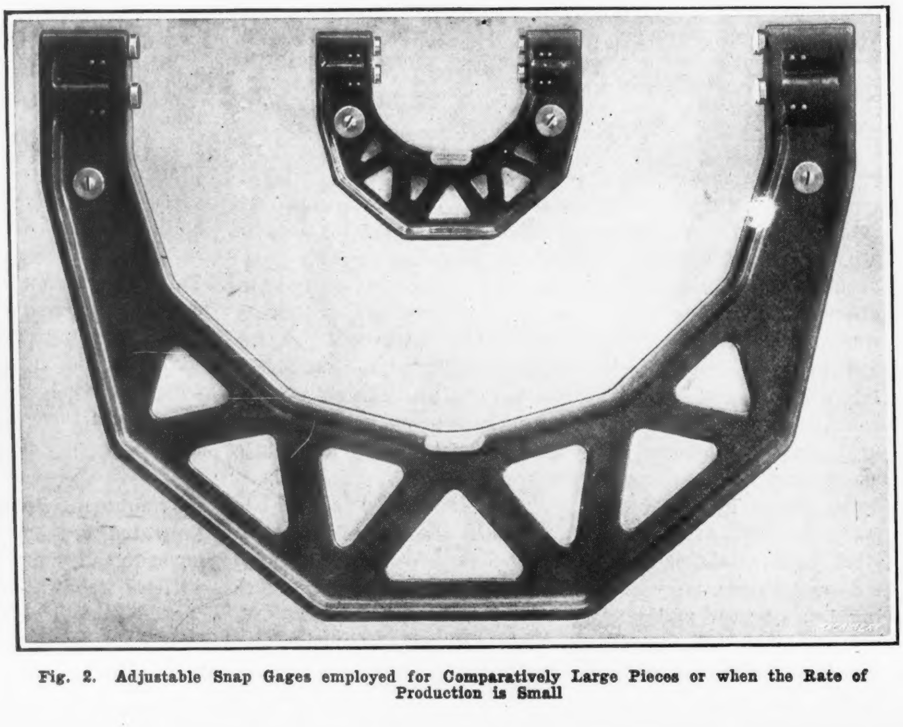


Fig. 2. Adjustable Snap Gages employed for Comparatively Large Pieces or when the Rate of Production is Small

In order to meet all these conditions, special measuring tools known as gages have been developed.

Gages are an integral part of interchangeable manufacturing equipment. They comprise that part of the equipment whose purpose is to measure the product, as distinguished from that part of the equipment whose purpose is to change the form of the material or to hold the part during a manufacturing operation. Under this broad definition of a gage, it is apparent that some of the manufacturing equipment may be not only a holding device, but also a gage. In fact it is good practice to make fixtures so that an unserviceable part cannot be inserted. It often happens that when the normal manufacturing variations of certain machining processes are small and within known limits, a gage may be employed to test the size or form of the cutting tool, and not be applied directly to the product. At other times, a gage in the form of a setting block for the position of the cutting tool is made as an integral part of the fixture. Therefore, to determine the character of the gages that are required for the production of any particular part, it is necessary to consider both the requirements of the part in question and the other manufacturing equipment that is provided.

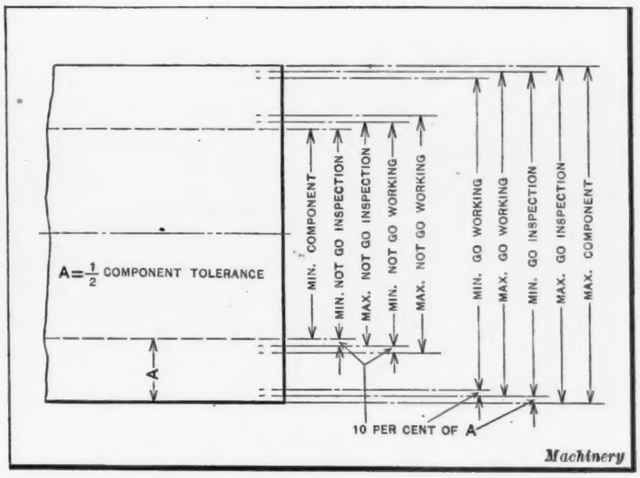


Fig. 3. Diagrammatic Illustration showing Differences between Working and Inspection Gages and Tolerances on these Gages

Classification of Gages According to their Use

In general, there are three purposes for which gages may be needed: First, in the manufacture of large numbers of duplicate pieces, it is a measure of economy to detect and discard all unserviceable parts as soon as possible, thus saving the expenditure of additional effort on such parts. The gages provided for the purpose are commonly known as working gages. These are often limit gages, placed in the hands of the machine operator to check each individual machining operation as it is performed.

Second, it is necessary to check the parts as they are transferred from one manufacturing department to another, and also before the finished parts are sent to the stock-room or assembling floor, so as to prevent unserviceable parts from proceeding farther. It is also customary to inspect the parts in process after certain groups of operations have been performed. The gages used for these purposes are commonly known as inspection gages. Some of these are limit gages which are often duplicates of some of the working gages, while others are functional gages which check the results of several operations at one time. These inspection gages are generally used by a force of inspectors who are independent of the production department.

Third, when gages are used to any extent, it is necessary to have reliable standards as a means of checking the working and inspection gages and to establish the sizes of new gages as the old ones wear out. Such standards are variously known as checks, reference gages, standards, master gages, and model parts. These gages are usually kept in the tool-room or in the hands of a gage inspector, and their purpose is to test the working and inspection gages so as to insure a suitable degree of precision in them.

Required Accuracy of Gages

Extreme refinement in gages is very expensive and is unwarranted by the functioning of the majority of component parts. The accuracy required by a gage depends in a great measure upon the extent of the manufacturing tolerances. If these tolerances have been properly established, only a small percentage of them will be exacting. It is evident that a gage used to measure a dimension which has a tolerance of 0.002 inch must be made closer to size than one which measures a dimension having a tolerance of 0.020 inch. It is common practice to establish the tolerance on a gage at 10 per cent of the component tolerance. A tolerance of less than 0.0002 inch should seldom be specified unless the conditions are unusually exacting and economy is no object.

With variations in gages, no matter how slight, and with parts passing through successive inspections, many misunderstandings are inevitable unless precautions are taken to guard against them. The most common method of meeting this condition is to establish the limits of the working gages inside the limits of the inspection gages. Fig. 3 is a diagrammatical illustration showing the differences between working and inspection gages and the tolerance on these gages. The full lines represent the maximum size of a part while the dotted lines represent the minimum size. The maximum size of the "Go" inspection gage is identical with the maximum size of the component. The minimum size of the "Go" inspection gage is 10 per cent of the component tolerance smaller than its maximum size. The maximum size of the "Go" working gage is identical with the minimum size of the "Go" inspection gage, while its minimum size is 10 per cent of the component tolerance smaller. In a similar manner,

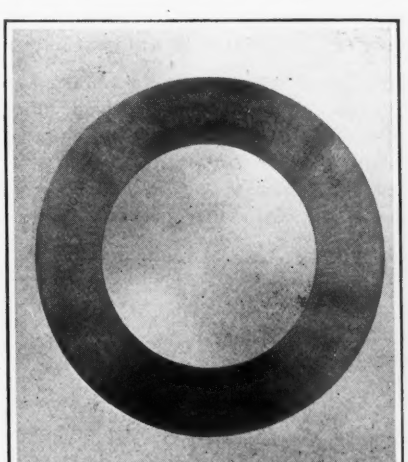


Fig. 4. A Ring Gage of the Ordinary Type

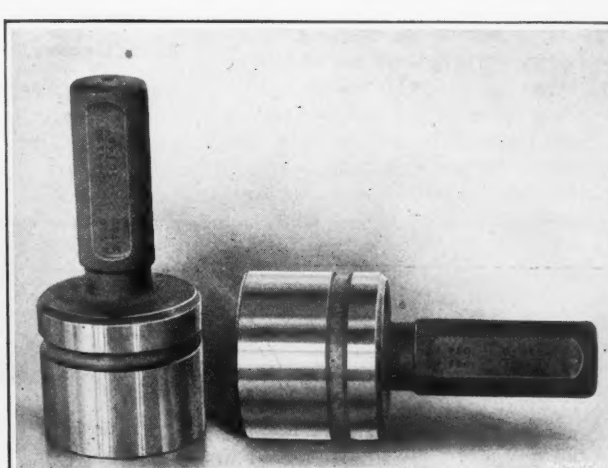


Fig. 5. Two-step Plug Gages used for the Inspection of Through Holes

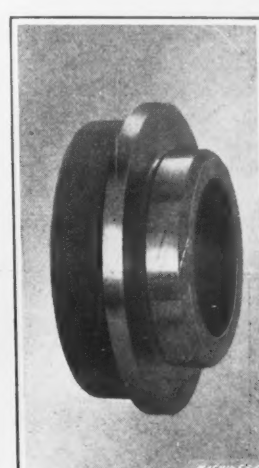


Fig. 6. Counterbore Plug Gage

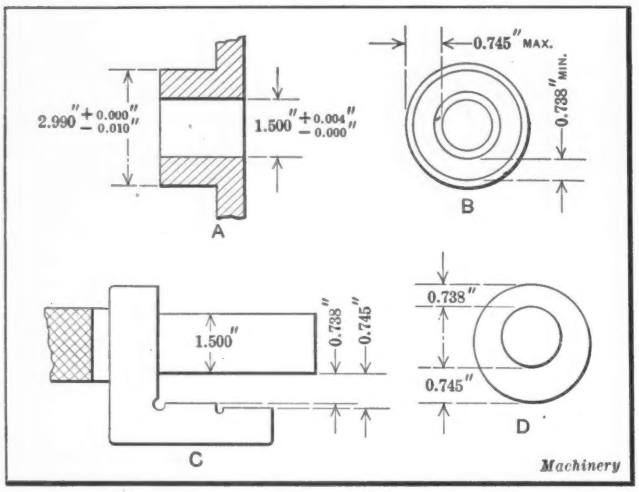


Fig. 7. Illustration showing how Compound Tolerances are involved when testing the Concentricity of a Hub with a Hole

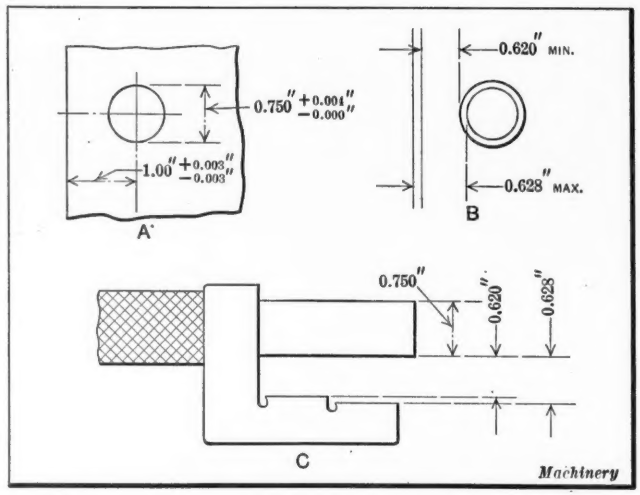


Fig. 8. Application of a Combination Plug and Snap Gage in testing the Location of a Hole from the Edge of a Part

the minimum size of the "Not Go" inspection gage is identical with the minimum size of the component while its maximum size is 10 per cent of the component tolerance larger. The minimum size of the "Not Go" working gage is identical with the maximum size of the "Not Go" inspection gage, while its maximum size is 10 per cent of the component tolerance larger. As the tolerance on the component increases, it is often advisable to reduce this percentage. Thus, for plain plug and snap gages, a tolerance greater than 0.001 to 0.002 inch is seldom necessary.

Desired Relation between Working and Inspection Gages

It is evident that if the sizes of the working gages are always kept inside of the sizes of the inspection gages, few questions should arise due to parts passing the working gages and being rejected by the inspection gages. This arrangement may be secured by making and maintaining the gages as outlined in the foregoing or by a process of selection and grading. If all the gages used at the same time for the same surface are checked concurrently, those permitting the widest variation in the product should be used as inspection gages, while the others should be used as working gages. In all cases the nominal sizes of the inspection limit gages should be identical with the limits of the component, and all tolerances should keep them within the limits of the component. Thus, the maximum gage may be smaller than its nominal size but never larger, while the minimum gage may be larger but never smaller.

Such a practice brings up two age-old arguments: First, that a 1-inch plug will not enter a 1-inch hole, and second, that the tolerances on the gages rob the manufacturer of some of the tolerances given on the drawing. The answer to these arguments depends upon the interpretation of the drawing. If this interpretation is that the dimensions and tolerances given on the drawing represent the extreme sizes of the limit gages, and all variations of whatever source must come within these limits, neither of the above arguments has any weight; and this is the only logical interpretation that can be used definitely and consistently. With this interpretation, it does not matter whether the hole is ever exactly one inch or not. As for the second argument, if the shop does not attempt to maintain its product within slightly smaller tolerances than the extreme tolerances, too large a percentage of parts will inevitably run outside of the tolerances and be rejected.

Gage Requirements Controlled by Ultimate Economy

A limit gage is one that measures both the maximum and minimum sizes of the component. Such gages usually check elementary surfaces, although they are at times provided for checking profiles and other composite surfaces. The most common types of limit gages are snap gages, plug gages, ring gages, depth gages, and length gages. A functional gage is one that checks primarily the functional operation of a component without strict adherence to its exact physical dimensions. Several types of these gages were discussed in "Component Drawings for Interchangeable Manufacture," published in the November and December, 1919, numbers of MACHINERY. The purpose of such a gage is to insure, as far as possible, the proper assembling and operation of all parts.

The extent to which gages should be employed depends on the product and the rate of production. If the rate of production is low, it is often possible to control the accuracy of the product with standard measuring instruments. As it increases, the time spent in using standard instruments reaches a point where the time saved by the use of gages more than pays for their cost. Gages should be provided for only those surfaces which it is essential to maintain within certain dimensions. Each gage should have its definite purpose just as any other piece of manufacturing equipment has some definite duty to perform. A gage is a preventive and not a cure. Gages are required wherever their use will tend to prevent the production of faulty work. Thus a more complete system of gages is necessary in a shop that employs a large percentage of semi-skilled labor than in a shop employing highly skilled operatives.

Interchangeability between Parts Made in Different Shops

Experience has shown it to be difficult to obtain interchangeable parts from several independent plants producing a common product unless great precaution is taken at the outset to insure this result. Under these conditions the most certain method is to maintain identical working and gaging points at the various plants for all functional surfaces.

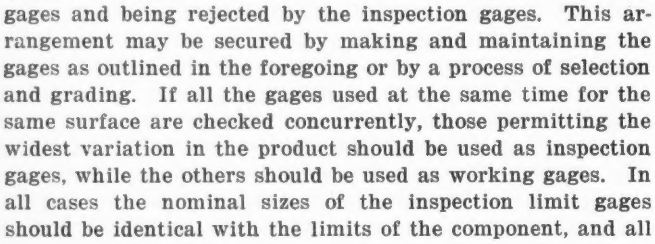


Fig. 9. Taper Plug Gage provided with Groove between the Edges of which the Face of the Work must be Flush

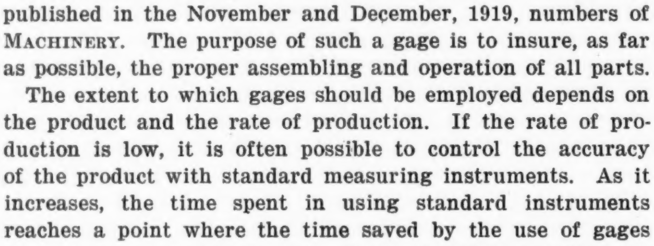


Fig. 10. Combination Plug and Snap Gage used for Such Purposes as testing the Concentricity of a Hub with a Hole

Fig. 11. Simple Type of Contour Gage for checking the Uniformity of Contours or Profiles

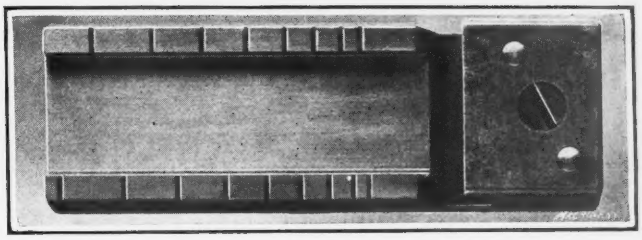


Fig. 12. Matching Gage used in testing the Positions of Graduations on a Part

Component drawings, properly dimensioned, assist greatly in accomplishing this end. This does not necessarily mean that the design of the gages must be identical. The exact design of a gage is never in itself a matter of great importance. The effectiveness and economy of the results obtained are the important considerations. Usually the gaging equipment must be very complete to meet successfully the requirements of interchangeability between independent plants.

For the further discussion of gages, they will be classified according to their type, such as snap gages, ring gages, plug gages, profile gages, thread gages, flush-pin gages, functional gages, etc. Many of the gages considered in this article were also described and illustrated in five articles dealing with gages and the development of a gaging system, which were published consecutively in MACHINERY beginning with the October, 1918, number. For this reason illustrations and lengthy descriptions of the gages previously treated are deemed unnecessary. By referring to these articles, other gages of an interesting character will also be noted.

Snap Gages

Gages were first developed as part of the equipment necessary for manufacturing large numbers of duplicate parts. Now gages are used to a large extent in the production of smaller numbers of parts. In this case, however, many modifications in the design, such as adjustable features, have been developed to keep the cost within reasonable limits. Snap gages for use in the manufacture of large numbers of interchangeable parts will be discussed first. The earliest form of snap gage was the "one-size" type; that is, a gage to measure one flat dimension only. This type is still used to a large extent in tool-rooms and machine shops when limits are not expressed on the drawings and when the clearances for the different fits are left to the judgment of the workmen.

The limit gage with two steps was later developed, one step being provided for measuring the maximum limit, and the other for measuring the minimum limit. For small parts produced in large quantities the non-adjustable gages are most satisfactory. Formerly a number of gage slots were cut in one piece of steel to permit a combination of gages in one piece, but the disadvantage of this design was that when one gage became worn the whole gage was lost. One method of overcoming this disadvantage is to have a filler block inserted on one side of the gage jaw which can be replaced when the gage becomes worn. Sometimes a combination of gages is mounted on a ring similar to a key ring. In a later snap gage construction, individual gages are assembled in convenient units and held together by clamping strips and screws. This construction permits the easy removal of a gage when necessary.

Various Other Types of Snap Gages

One type of snap gage has an intermediate step between the two limit steps, to aid the machine operator in setting up and adjusting the tools. In setting up a machine for repetition work, the object is to set the tools so as to have the maximum time between adjustments. When a circular part is machined with a form tool or a box-tool, the piece becomes larger as the tool wears. Therefore, the initial setting should be as near the minimum or "Not Go" limit as other conditions will permit. The intermediate step on these working snap gages is made to approximately the mean dimension. Thus, if the operator sets the machine to produce work between the minimum limit of the gage and the intermediate step, the life of the tool, as regards wear at the particular setting, is equal to at least half of the working tolerance. These intermediate steps are not used on inspection gages, as they would serve no purpose there.

There are two general types of snap gages, those with deep throats for measuring diameters and those with shallow throats as illustrated in Fig. 1, for measuring lengths. When the gage slot is very narrow, snap gages are frequently made with a removable strip serving as one side of the gage slot. This construction permits the gaging surfaces to be readily ground.

For larger pieces and for smaller rates of production, adjustable snap gages have been developed. Gages of this type are shown in Fig. 2. In common with other types of adjustable tools, these should be adjustable in the tool-room and fixed in the manufacturing departments. This result is obtained by providing a place for a seal which must be broken before the gage can be adjusted, thus preventing the adjustment from being tampered with. These gages may be readily adjusted in the tool-room to any desired limits, so that a few sets of them provide a flexible and economical equipment of gages for checking elementary dimensions, such as external diameters, thicknesses, and lengths.

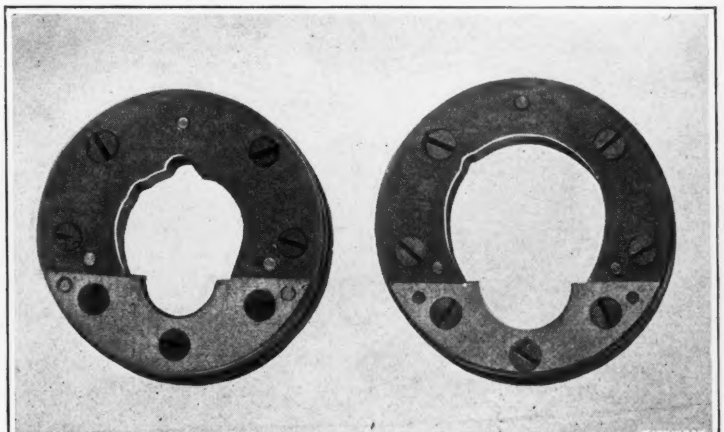


Fig. 13. Receiving Gages having Holes or Openings corresponding to the Shape of the Part inspected by them

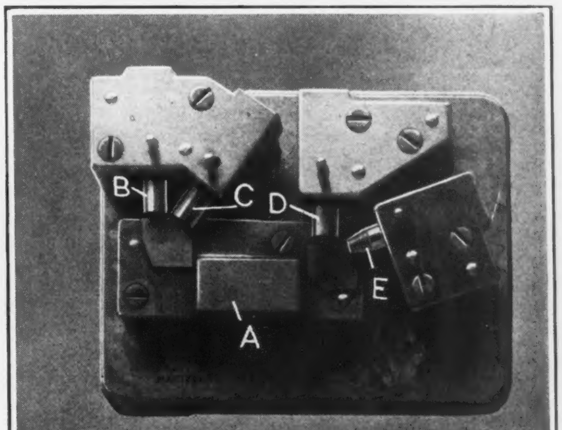


Fig. 14. Profile Gage which checks the Contour of the Work by Flush Pins

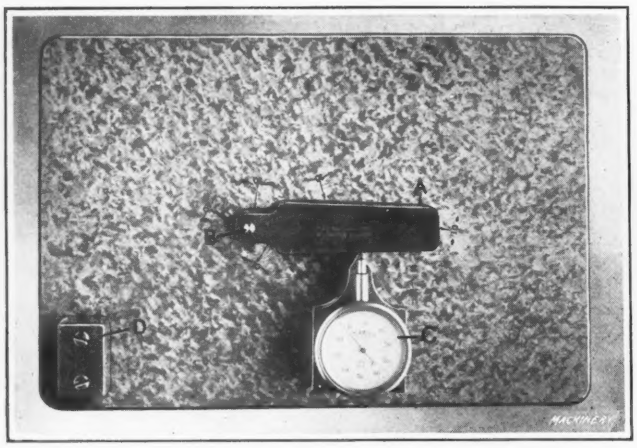


Fig. 15. Dial Indicator Contour Gage having a Baseplate, the Point of which is in Contact with a Master Form, while the Point of the Indicator is in Contact with the Work

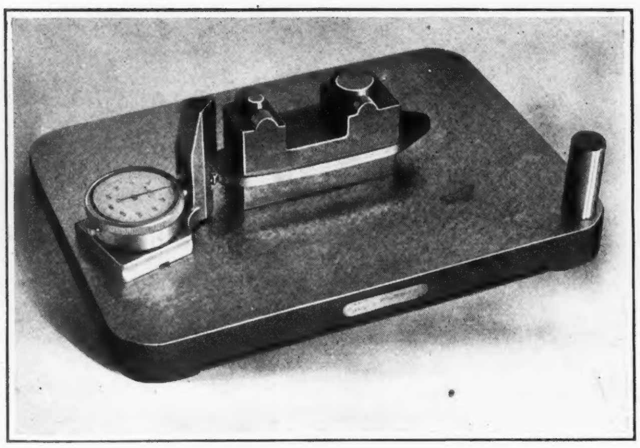


Fig. 16. Type of Dial Indicator Contour Gage on which the Point of the Indicator is in Contact with the Master Form while a Projection on the Baseplate registers against the Work

Ring Gages

Under some conditions, the use of a snap gage for testing diameters is not sufficient, and in such cases ring gages are employed. Wherever possible, however, snap gages should be employed, as they are more economical to use. A snap gage can be used more rapidly than a ring gage. Furthermore, on many parts, a machine operator cannot use a ring gage without removing the work from the machine. The extent of the tolerance required to manufacture a part economically depends in a large measure on the type of gage employed. For example, if a ring gage is used in place of a snap gage, any departure from rotundity or from size affects the acceptance of the part by the gage. Thus, in effect, a snap gage checks an elementary surface while a ring gage checks a composite one.

The severest possible inspection of a cylindrical surface is obtained by the use of "Go" ring gages and "Not Go" snap gages. It is therefore evident that a description of the gaging and inspection methods is essential in the specifications to avoid misunderstandings. The larger ring gages are made as individual gages, as shown in Fig. 4, and are sometimes provided with handles. Several small ring gages are often inserted into a soft holder which keeps them together.

Plug Gages

Plain plug gages are old and simple forms. Standard plug gages, as with standard snap gages, are largely used in toolrooms and general machine shops. A "Not Go" gage was a later development and is attached either to the other end of the same handle as the "Go" gage or is a separate gage. It is common practice to make standard handles and standard plug gage blanks, later finishing these blanks to the size required and assembling them into the standard handles. Solid double-ended plug gages are open to the same objections as solid combined snap gages. If one end becomes unserviceable, the whole gage must often be discarded. The heading illustration shows a set of standard limit plug gages ranging from ¾ to 3 inches in diameter. The minimum or "Go" ends are made longer than the maximum or "Not Go" ends; this practice is followed in order to make the "Go" end readily distinguishable from the "Not Go" end, and, furthermore, as the "Not Go" end is subject to little wear, there is no necessity for making it very long.

When a through hole is to be gaged, it is customary to make a two-step plug gage such as shown in Fig. 5. This permits rapid inspection, but the gage cost is greater than when two separate ends are used. Often, however, the saving in inspection costs will greatly exceed the additional expense of this type of gage, so that the practice is economical in the long run.

The Pratt & Whitney Co. manufactures a gage known as the "star" gage, which is of the expansion type, having four movable measuring ends. This gage is used for measuring the bores of tubes and jackets for large guns, the bores of engine cylinders, etc. Plug gages made from flat stock are often used to measure the width or length of slots or grooves. These gages are frequently rounded at the end and used for measuring the length of a splined slot.

Plug Gages for Several Surfaces and Taper Surfaces

Thus far only gages for elementary surfaces have been considered. The dimensions for such gages are readily determined from the limits expressed on the component drawings. To test concentricity, however, the assembly requirements of the mating parts must be considered. This has been previously discussed in the articles mentioned in the foregoing. A gage of this type for testing the concentricity of the bore and counterbore of the main bearing of an automobile transmission case is shown in Fig. 6. Plug gages are often made with steps on the end to gage both the diameter and the depth of a hole at the same time. At other times a sliding collar is provided which saves the use of a straightedge if the hole to be gaged is either countersunk or counterbored.

Taper plug gages are usually provided with either lines or steps to gage not only the diameters of the tapered hole, but also their locations. A taper gage is shown in Fig. 9. A groove is cut near the large end of this gage and the width

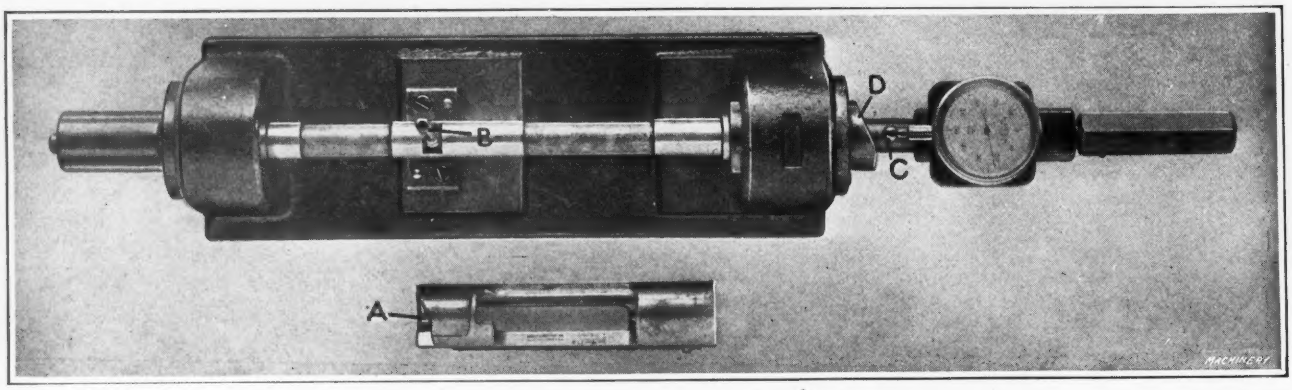


Fig. 17. Application of the Dial Indicator Contour Gage in inspecting the Cam Surface of a Part

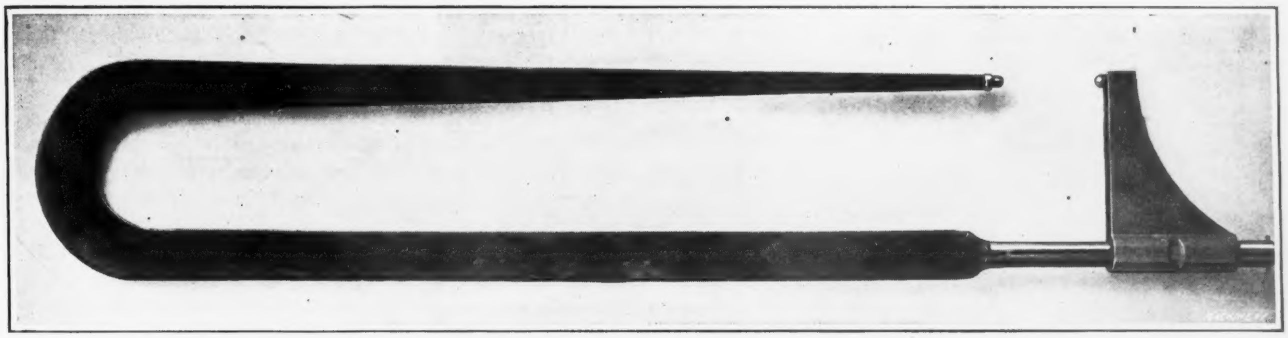


Fig. 18. Sliding-bar Gage used in testing the Thickness of the Bottom of a Shell, and provided with an Arm which can be swung out of the Way to permit the Gage to enter the Work

of this groove indicates the limits. The gage must go into the work until one edge of the groove is flush with or below the face of the part, while the other edge must never go in beyond the face of the part. Sometimes steps are provided to indicate the limits and at other times, lines are graved to serve the same purpose. If the tapered hole is properly dimensioned on the component drawing so that no compound tolerances exist, the correct dimensions of the gage are readily determined. If compound tolerances exist on the drawing, however, some arbitrary method of interpretation must be promulgated or else endless arguments will ensue about the proper gage sizes. This subject has also been discussed in the articles previously referred to.

Application of Combination Plug and Snap Gages

A combination plug and snap gage is illustrated in Fig. 10. Such gages may be required for several purposes. They may be used to test the concentricity of a hub with a hole, the location of a hole from the edge of a part, the depth of a slot in relation to a hole, etc. In determining the dimensions of such gages, compound tolerances are almost inevitably present. Therefore, some arbitrary method of interpreting the drawing must be established. A gage for testing the concentricity of the hub with a hole will be considered first.

Assume that the hub and hole represented at *A* in Fig. 7, must be gaged. The diameter of the plug in this case will be taken as the minimum size of the hole or 1.500 inches. If it is considered that the limits given for the hole and hub establish parallel zones of permissible variations, as shown at *B*, there will be a minimum distance of 0.738 inch between the gaging parts of the combination gage shown at *C*, and a maximum distance of 0.745 inch. The use of this gage will then permit the extreme condition of eccentricity which is shown at *D*. If the diameter of the hole is maximum and the eccentricity is at this extreme, the size of the hub will be 2.987 inches. If the diameter of the hole is minimum, the size of the hub will be 2.983 inches. The more nearly concentric the hole and hub are maintained, the greater the amount of tolerance which remains for their diameters. The full tolerance on these diameters becomes available only when they are concentric with each other. It may be pointed out that the condition shown at *D* does not keep the parts within the parallel zones shown at *B*. This is true, and will be found to be true wherever compound tolerances are involved. It is this condition that makes it necessary to establish some arbitrary interpretation of the drawings.

The next example will be of a combination plug and snap gage used to test the location of a hole from the edge of a part. The procedure to determine the gage sizes is identical with the foregoing. A part having a hole which is to be gaged from an edge is shown at *A*, in Fig. 8. The parallel zones of variation given on the drawing are shown at *B*, and the gage is shown at *C*. The diameter of the plug is shown as the minimum size of the hole. As a matter of fact, the diameter of the plug may be any size smaller than the hole in these cases, as the gaging dimension is controlled by the gap between the edge of the plug and the steps of the arm. A plug of minimum size is generally used so that it may also be employed as the "Go" gage for the hole. A modification of this gage is used to test the position of a hole that must be carefully located between two edges. One side of the snap gage part is made longer than the other to detect the side at fault in case the gage does not go on.

Contour or Profile Gages

Contours or profiles are among the most difficult surfaces to gage properly. A contour gage of the earliest type is shown in Fig. 11, but this type should be used only when accuracy is not important. The main objection to this form is that it measures only the shape of the work and not the location of the contour. A gage designed to overcome this objection has guides for the contour and locating points for the work. This type of gage was illustrated and described in an article entitled "Contour or Profile Gages," in the December, 1918, number of MACHINERY.

Contour gages of the matching type are sometimes used when great accuracy is not required. The part is placed on the gage and its outline compared, either visually or by a straightedge, with the outline of the gage. In Fig. 12 is shown one type of matching gage. This is used to test the

Fig. 19. Simple Form of Flush-pin Gage, consisting of a Plunger which slides in a Sleeve

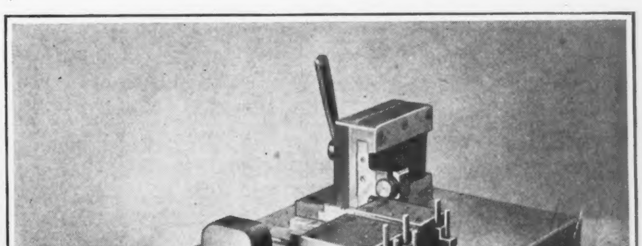


Fig. 20. Gages with Three Sets of Double Flush Pins for measuring an Irregular Slot in a Part

position of graduations on a part. The work is inserted in the gage and the graduations are compared visually. Similar gages are often used for checking the shape of springs made from flat stock and also for checking the graduations on dials, etc.

Receiving Gages

The simplest form of receiving gage is a flat templet in which a hole or opening is cut corresponding to the form of the part to be inspected. Such gages do little more than insure interchangeability. If the part enters, it is not too large, but it is impossible to determine from such a gage if the piece is too small. If the piece does not enter, it is too large. It is difficult to find the exact location and amount of the error. Gages of this type are shown in Fig. 13. In an improved type of receiving gage the work is inserted in the opening of the gage and properly located there. This opening is a uniform distance from the work so that maximum and minimum plug gages may be inserted between the work and the gaging surfaces.

This same principle may be applied to the gaging of irregular openings by making a male profile a uniform amount under size and using limit plug gages to check for errors. Fig. 14 shows another type of profile gage which checks the contour to definite limits. In this case the contour consists of several flat surfaces cut at different angles. The part is located by block *A*. The flush pins *B*, *C*, *D*, and *E* check the various faces on the piece.

Dial Indicator Contour Gages

The highest development in gages for formed surfaces is doubtless the dial indicator contour gage, a simple example of which is shown in Fig. 15. This type of gage consists of a baseplate which has mounted on it means for holding the piece to be gaged as well as the master form with which the piece being gaged is compared. The piece to be gaged is shown in position at *A*, and the master form is directly beneath it. The stud *B* is used to locate the work. The dial indicator *C* is mounted on a baseplate of its own and slides on the baseplate of the gage. The point on the baseplate of the indicator is brought in contact with the master form, while the point of the indicator itself is in contact with the piece to be gaged. The amount and direction of the tolerance is stamped on the face of the gage baseplate. At *D* is shown a setting block which is used to set the indicator to zero.

This type of gage makes it possible to determine quickly and accurately whether the work is within the prescribed limits. The tolerances on the work may be varied along the contour, and the indicator will show the variations at any point. The wear on these gages is almost negligible, as the master form is in contact only with the small hardened point of the block on which the dial is mounted. These gages are very convenient for gaging slots having irregular bottoms.

Sometimes these gages are made so that the point of the dial indicator follows around the master form, while a projection on the baseplate registers against the work. Such a gage is shown in Fig. 16. Otherwise its operation is the same as in the previous example. This type of gage lends itself readily to the inspection of work having many difficult and exacting requirements. A modification is shown in Fig. 17. The piece to be gaged is shown below the gaging fixture. This gage is used for inspecting the cam surface *A*. In operation, the pin *B* follows the cam surface *A*, while the point *C* on the dial indicator follows the master cam *D*. Any variations are thus readily and accurately detected. This type of gage is not limited to the gaging of contours, but may also be used for testing depths, steps, recesses, etc., much more readily than a great number of snap, plug and depth gages.

Flush-pin Gages

Flush-pin gages are generally used for tolerances over 0.002 inch, especially in cases where snap gages cannot be applied conveniently. It is possible to use them for smaller tolerances, but it is seldom practicable in such cases to depend on the sense of touch. The flush-pin gage in its simplest form, as shown in Fig. 19, consists of a plunger which slides in a sleeve. Steps are provided, sometimes on the top of the plunger and other times on the sleeve, which agree with the specified tolerances. The dimension to be gaged is represented by the projection of the plunger beyond the bottom of the sleeve. The same principle may be applied in a great variety of ways. Fig. 14 shows its application to a contour gage.

The advantages of flush-pin gages may be briefly summarized as follows: The flush-pin gage is the simplest form of gage for measuring the position of one surface with reference to a locating point, when the relation is such that a snap gage cannot be used. Flush-pin gages are subject to a comparatively small amount of wear, and repairs are simple. Mistakes in reading the indications on them are rare.

Sliding-bar Gages

Among the gages made with sliding members, the sliding-bar gages occupy an important place. In principle, they are similar to flush-pin gages, but differ in the method of taking the readings or indications. A common type is similar to a micrometer in general construction. On the sliding bar is engraved a line, which must be between two steps on the frame if the part being measured is acceptable. Another similar example is shown in Fig. 18. Two lines are engraved on the cylindrical part of the frame, while a single line is engraved on the slotted surface of the sliding arm. The arm swings out of the way to allow the gage to enter the work. This gage is used to measure the thickness of the bottom of a shell, and is made light for ease of operation, as the work itself is too heavy to be handled rapidly.

Fig. 20 shows a gage with three sets of double flush pins for measuring the irregular slot in the piece shown at *A*. On sliding-bar gages where the tolerance is too small to be read from lines engraved on the plunger, the movement of the bar is multiplied by a lever which points to a graduated scale on the side of the gage. In this way it is possible to note quickly whether the work is machined within the requirements or not.

The next installment of this article, which will be published in the August number of MACHINERY, will illustrate and describe flat-depth and length gages; hole gages; thread gages; wing and indicator gages; functional gages; gear gaging machines; special gages; and master and reference gages.

* * *

EXTENDED USE OF HYDRO-ELECTRIC POWER

Under the heading "America's Electrical Opportunity," the *Scientific American* calls attention to the great scarcity of coal in many countries of Europe. This has focussed the attention on the advantages of electricity derived through water-power development. There was never a time when so much business was available to American manufacturers, provided some means for extending credits can be devised. In Italy, for instance, the authorities are planning the electrification of 3700 miles of railroad. Portugal plans to electrify all its railroads. France is casting about for water-power development projects. Nineteen large generating stations are planned in the Rhone valley, which will furnish 12,000 to over 70,000 horsepower each. The entire project will probably mean 760,000 horsepower. South America is also interested in hydro-electric developments.

* * *

It has been announced that at the annual meeting of the American Foundrymen's Association, to be held in Columbus, Ohio, October 4 to 8, a non-ferrous casting section will be added to the program. At the meetings of this section, papers and discussions of interest to the practical brass and aluminum foundrymen will be presented. The Institute of Metals division of the American Institute of Mining and Metallurgical Engineers will hold a convention in Columbus during the same week, and it is proposed to have joint sessions of this body with the new non-ferrous section.

Hardening Shop Costs

A Review of Methods for Estimating Costs in the Hardening Room, Including All the Elements Involved in Carburization and Casehardening

By S. P. ROCKWELL,* Metallurgist, Weekes-Hoffman Co., Syracuse, N. Y.

OFTEN it is desired to know the cost of hardening certain classes of work going through the shop, or work which may be submitted for a price estimate. The following is a quick method of determining costs, and answers the purpose very satisfactorily: Assume that the costs of building, equipping, and running a hardening shop are as follows: Building, $12,000; oil-fired carburizing furnace, three chambers, eighteen pots each, $2500; two oil-fired hardening furnaces, each $800; tempering furnace, $200; special hardening machine, $1500; straightening machine, $200; hardness testing machine, $285; pumps, oil tanks, etc., $3000; malleable iron pots, per pot $9.375; carburizing material, per ton, $75; fuel oil, per gallon, 7 cents; quenching oil per gallon, 30 cents; tempering oil, per gallon, 40 cents; power, per kilowatt-hour, 4 cents; superintendence and laboratory, per year, $3000; foreman, per day, $8; labor, per hour, 45 cents; and miscellaneous expenses, such as office stationery, light, heat, water, insurance, per year, $3000.

For convenience, the costs of the hardening shop are divided among the three following operations: (1) Carburizing, which includes the costs of packing, carburizing, cooling in the pot or quenching from the pot, unpacking and delivering to the hardening department. (2) Hardening, which includes the costs of heating for core and case refinements and delivering to tempering and inspection department. (3) Tempering and inspecting. On account of the floor space and labor required in carburizing, 50 per cent of the total sum of such items as building, superintendence, equipment, etc., is charged to this operation. Of the remaining cost of these items, 25 per cent is charged to hardening, allowing 12.5 per cent for hardening for core refinement, and 12.5 per cent for hardening for case refinement; and the remainder, or 25 per cent, is charged to tempering and inspecting. It is assumed that the shop is operated 10 hours per day or approximately 3000 hours per year.

Carburizing Costs

The method of figuring the carburizing costs of the various items per pot per hour, is as follows:

Building—If 10 per cent of $12,000, or $1200, is allowed for interest and depreciation per year, then 50 per cent of this amount, or $600, should be charged to carburizing. Allowing 3000 working hours per year, the cost per hour is $600 ÷ 3000 = 20 cents. By dividing this amount by 54 (the pot capacity of the carburizing furnace), the building expense per pot per hour is 20 ÷ 54 = 0.37 cent.

Carburizing Furnace—If 6 per cent of the cost is allowed for interest and 12 per cent for depreciation per year, this will amount to 18 per cent of $2500, or $450, and $450 ÷ 3000 = 15 cents, the furnace cost per hour. The cost per pot per hour, equals 15 ÷ 54 = 0.277 cent.

Pumps, Oil Tanks, etc.—Allowing 20 per cent for interest and depreciation per year, this would amount to 20 per cent of $3000, or $600; but only 50 per cent of this, or $300, is chargeable to carburizing. The total cost per hour equals $300 ÷ 3000 = 10 cents, and the cost per pot per hour, equals 10 ÷ 54 = 0.185 cent.

Malleable Iron Pots—Considering the average life as 500 hours, the pot cost per hour is $9.375 ÷ 500 = 1.875 cents.

Carburizing Material—If it has been determined that the material can be used four times, the cost per useful ton is $75 ÷ 4 = $18.75. The cost per pound is $18.75 ÷ 2000 = 0.937 cent. If 30 pounds is used per pot and the material is good for a ten-hour heat, the cost of the material per pot per hour is 0.937 × 30 ÷ 10 = 2.81 cents.

Fuel—If one chamber of the furnace uses 3 gallons of oil per hour the cost is 3 × 7 = 21 cents. This amount divided by 18, the number of pots in one chamber, gives the cost per pot per hour as 1.167 cents.

Power—If 4 horsepower is required for the air blast, at 4 cents per kilowatt-hour this cost equals 2.983 × 4 = 11.932 cents, and the cost per pot per hour equals 11.932 ÷ 54 = 0.221 cent.

Foreman and Superintendence—Fifty per cent of the foreman's salary or $4 per day should be charged to carburizing. Likewise, 50 per cent of superintendence and laboratory costs, or $1500 per year, should be charged to this work. This amounts to $5 per day, so that the costs of both these items per day is $9 or 90 cents per hour and 90 ÷ 54 = 1.667 cents, the cost per pot per hour.

Labor—The cost for three laborers at 45 cents per hour brings this expense to $1.35 per hour, and $1.35 ÷ 54 = 2.5 cents, the labor cost per pot per hour.

Miscellaneous Expenses—Fifty per cent of this item, or $1500 per year, is chargeable to carburizing, so that $1500 ÷ 3000 = 50 cents, the cost per hour. The cost per pot per hour equals 50 ÷ 54 = 0.926 cent.

The following is a summary of the costs per hour, in cents of the various items for carburizing one pot of work:

Building	0.370
Carburizing furnace	0.277
Pumps, oil tanks, etc.	0.185
Malleable iron pots	1.875
Carburizing material	2.810
Fuel	1.167
Power	0.221
Foreman and superintendence	1.667
Labor	2.500
Miscellaneous expenses	0.926
Total cost per pot per hour	11.998

In order to find the cost per piece or pound of work for carburizing, it is necessary to divide 11.998 cents by the number of pieces or pounds that may be packed in a pot and multiply this amount by the number of hours in the heat. Assuming that 6 ring gears requiring an 8-hour heat can be packed in 1 pot, the cost per piece would equal 11.998 × 8 ÷ 6 = 16 cents.

Cost of Hardening for Core Refinement

In estimating the cost of hardening for core refinement, 12.5 per cent of the total costs of such items as building, superintendence, etc., is chargeable to this operation, as previously mentioned. As 50 per cent of this cost was charged to carburizing, the amount to be charged to hardening for core refinement will be 25 per cent of the amount charged to carburizing. The method of finding the hardening for core refinement costs per day of the various items is as follows:

Building—Twenty-five per cent of 20 cents (the cost charged to carburizing) = 5 cents, the cost per hour. The cost per day equals 10 × 5 = 50 cents.

Furnace—If 6 per cent is allowed for interest and 18 per cent for depreciation, this cost will equal 24 per cent of $800 or $192 per year. The cost per day equals $192 ÷ 300 = 64 cents.

Pumps, Oil Tanks, etc.—As this equipment is not used in tempering, the cost chargeable to hardening for core refine-

ment is equal to 50 per cent of 10 cents (the cost charged to carburizing) = 5 cents or the cost per hour. As this equipment is used 13 hours per day the cost per day is 13 × 5 = 65 cents.

Fuel—If 2.5 gallons of oil is used per hour and the furnaces are operated 13 hours per day, the cost of fuel per day equals 2.5 × 13 × 7 = $2.275.

Quenching Oil—If 2 gallons is used per day, 2 × 30 = 60 cents, the cost per day.

Power—If 2 horsepower or 1.49 kilowatts is used per hour for 13 hours, the cost per day equals 1.49 × 13 × 4 = 78 cents.

Foreman and Superintendence—Twenty-five per cent of $9 (the cost charged to carburizing) = $2.25, the cost per day.

Labor—If one man is employed for this work, the cost is 10 × 45 = $4.50 per day.

Miscellaneous Expenses—Twenty-five per cent of 50 cents (the cost charged to carburizing) = 12.5 cents, the cost per hour. The cost per day equals 10 × 12.5 = $1.25.

The following is a summary of the various costs per day of hardening for core refinement:

Building	$0.50
Furnace	0.64
Pumps, oil tanks, etc.	0.65
Fuel	2.28
Quenching oil	0.60
Power	0.78
Foreman and superintendence	2.25
Labor	4.50
Miscellaneous expenses	1.25
Total cost per day	$13.45

The total cost per hour would equal $13.45 ÷ 10 = $1.34. In order to find the cost of core refinement per piece or pound of work, divide $1.34 by the number of pieces or pounds that can be hardened in one hour. Assume that it is desired to harden, for core refinement, the ring gears that were carburized, and that the time required for heating each gear is 15 minutes. If 25 gears can be laid on the floor of the furnace and after being heated for 15 minutes can be quenched in 5 minutes, the total time required for hardening 25 gears is 20 minutes, so that the output per hour would be 75 gears. If the cost per hour of operating the shop is $1.34 the cost per piece is $1.34 ÷ 75 = 1.79 cents.

Cost of Hardening for Case Refinement

Many of the costs of hardening for case refinement are identical with those charged to hardening for core refinement, so that it is unnecessary to show how these values are obtained. If two laborers are used in this process, this cost is double the cost in hardening for core refinement. If 10 per cent is allowed for interest and depreciation of the special hardening machine, this cost will equal 10 per cent of $1500, or $150, so that $150 ÷ 300 = 50 cents or the cost per day. The following is a summary of the costs der day of refining for core refinement.

Building	$0.50
Furnace	0.64
Pumps, oil tanks, etc.	0.65
Special hardening machine	0.50
Fuel	2.28
Quenching oil (if used)	0.60
Power	0.78
Foreman and superintendence	2.25
Labor	9.00
Miscellaneous expenses	1.25
Total cost per day	$18.45

The total cost per hour would equal $18.45 ÷ 10 = $1.85. In order to find the cost of case refinement hardening per piece or pound, divide $1.85 by the number of pieces or pounds of work that can be hardened per hour. Assuming that 300 of the ring gears previously carburized and hardened for core refinement are treated per day in one furnace, and that the hardening is done in a Gleason machine using oil for quenching, the output per hour is 30 gears. Then if the cost of hardening for case refinement is $1.85 per hour, the cost per gear is $1.85 ÷ 30 = 6.17 cents.

Costs of Tempering and Inspecting

In estimating the costs of tempering and inspecting, 25 per cent of such items as building, superintendence, etc., are chargeable to these operations and as 50 per cent of these items was charged to carburizing, the amount to be charged to tempering and inspecting will be 50 per cent of the amount charged to carburizing. The method of finding the costs of the various items is as follows:

Building—Fifty per cent of 20 cents (the cost charged to carburizing) = 10 cents, the cost per hour. The cost per day equals 10 × 10 = $1.

Tempering Furnace—If 20 per cent of the cost is allowed for interest and depreciation, this cost per year is 20 per cent of $200, or $40, and the cost per day equals $40 ÷ 300 = 13.33 cents.

Straightening Machine—If 10 per cent of the cost is allowed for interest and depreciation per year, this equals 10 per cent of $200, or $20, and the cost per day equals $20 ÷ 300 = 6.67 cents.

Hardness Testing Machine—If 10 per cent of the cost is allowed for interest and depreciation per year, this equals 10 per cent of $285, or $28.50, and the cost per day equals $28.50 ÷ 300 = 9.5 cents.

Fuel—If 1 gallon is used per hour, the cost per day is 10 × 7 = 70 cents.

Tempering Oil—If 4 gallons is used per day this cost equals 4 × 40 = $1.60.

Foreman and Superintendence—Fifty per cent of $9 (the amount charged to carburizing) = $4.50, the cost per day.

Labor—Two men employed for this work would cost 2 × 45 × 10 = $9.

Miscellaneous Expenses—Fifty per cent of 50 cents (the cost charged to carburizing) = 25 cents, the cost per hour, and 25 × 10 = $2.50, the cost per day.

The following is a summary of the various costs per day, for tempering and inspecting.

Building	$1.00
Tempering furnace	0.13
Straightening machine	0.07
Hardening testing machine	0.10
Fuel	0.70
Tempering oil	1.60
Foreman and superintendence	4.50
Labor	9.00
Miscellaneous expenses	2.50
Total cost per day	$19.60

The total cost per hour will equal $19.60 ÷ 10 = $1.96, and in order to find the cost per piece or pound of work for tempering and inspecting, divide $1.96 by the number of pieces or pounds that can be tempered and inspected per hour, assuming that thirty of the gears that have been given the preceding heat-treatments are tempered and inspected per hour, the cost per gear is $1.96 ÷ 30 = 6.53 cents. The total cost of performing the various operations on each gear can then be summed up as follows.

Carburizing, in cents	16.00
Hardening for core refinement, in cents	1.79
Hardening for case refinement, in cents	6.17
Tempering and inspecting, in cents	6.53
Total cost per gear, in cents	30.49

This article is the last one in the series relating to carburizing and casehardening which began in the January number of MACHINERY, and which has dealt with the various matters relating to this work that must be considered in a practical hardening department.

* * *

According to the National Automobile Chamber of Commerce, this country exported 67,106 passenger cars, valued at $73,642,035 in 1919, as against 36,936 cars, valued at $36,278,292 in 1918. The heaviest increases were shown in the South American trade. Canada, the largest buyer of American cars, took 8222 passenger cars and 1596 trucks. Truck exports numbered 15,467, valued at $35,099,079, as against 10,308, valued at $26,814,952 in 1918.

Modern Broaching Practice

Second of Two Articles Describing Methods and Fixtures Used in Performing Broaching Operations

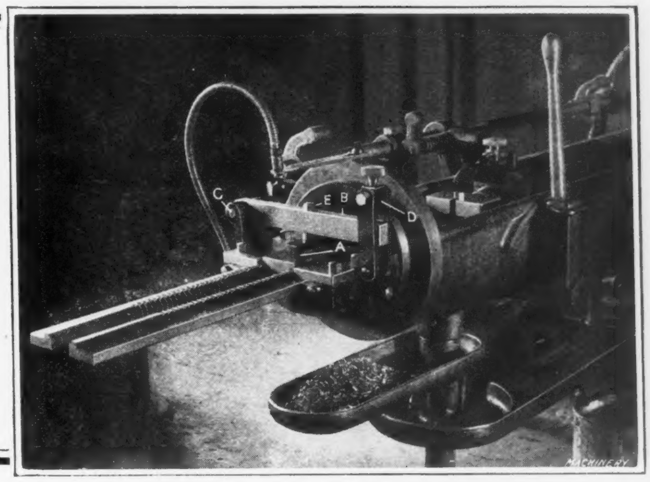


Fig. 14. External Broaching Operation

THE first article on this subject, published in the June number of MACHINERY, discussed general classes of work that can be broached; accuracy attained in broaching; coolants used for broaching; and procedure in ordering broaches. Broaching methods and fixtures employed for specific jobs, were described and illustrated. In the following article, the description of broaching methods and fixtures for holding and locating the work is continued.

Broaching Operation as a Substitute for Milling

In the general discussion of the range of work that can be handled on broaching machines in the June number, mention was made of the fact that it is often possible to broach certain classes of work which might ordinarily be regarded as typical jobs for a milling machine. An example of this kind is illustrated in Fig. 14, where it will be seen that the work *A* is to have a portion of the metal cut away along each edge of its under side. A job of this kind could quite well be handled on a milling machine equipped with two form cutters to straddle-mill the work, and by making a suitable string fixture a very satisfactory rate of output would be secured. Experienced milling machine operators can draw their own conclusions as to the relative merits of milling or broaching these pieces, when it is known that on the broaching machine ten of these cast-steel parts are completed per hour. Very little discussion of the work-holding fixture is necessary. It will be seen that strap *B* is pivoted at *C* and provided with a clamping member *D*. After strap *B* has been secured in place, nut *E* is tightened to hold the work in place on the fixture. Of course, it will be evident that each of the broaches is formed to remove a segment of metal of desired shape.

Broaching out the Center of a Small Casting

Fig. 15 shows the equipment utilized for broaching small castings which constitute parts of one of the equipments made by the Cleveland Dental Mfg. Co., Cleveland, Ohio. The job consists of broaching out a cored opening in the work. A simple form of fixture is used for this purpose, and reference to the illustration will show that it has a fixed jaw *A* and an adjustable jaw *B* that grip the edges of a flange *C* at the base of the casting, the movable jaw being manipulated by two adjusting screws *D* and then clamped in place by tightening two screws *E*. It will be apparent that the work is of considerable height and that this overhang would be sufficient to cause an objectionable amount of springing and vibration if an adequate upper support were not provided. This support consists of a block *F* mounted on the vertical slide, so that it can be lowered into place against the work, after which binding screws *G* are tightened to maintain a permanent location. From the front view of the casting held in place in the fixture, it will be apparent that the opening to be broached is shown at *H*, and the broach used for this fixture is of a narrow rectangular cross-section. Following the usual practice, the work-holding fix-

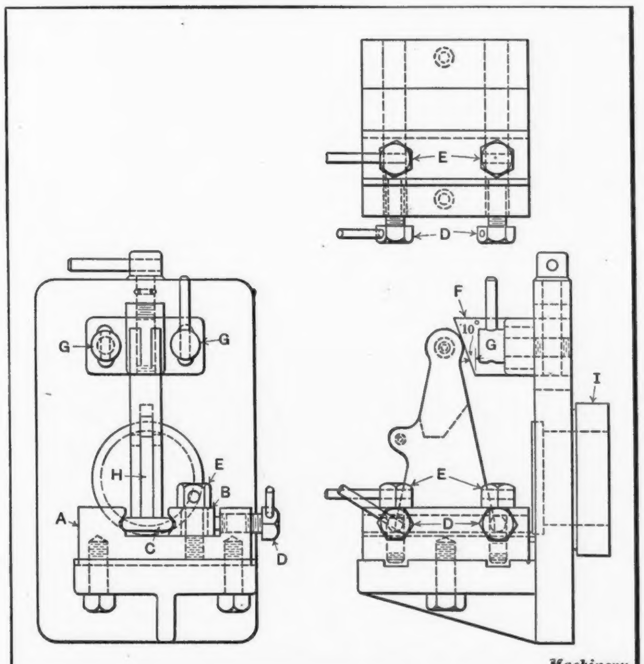


Fig. 15. Work-holding Fixture used for broaching out the Cored Hole shown at H

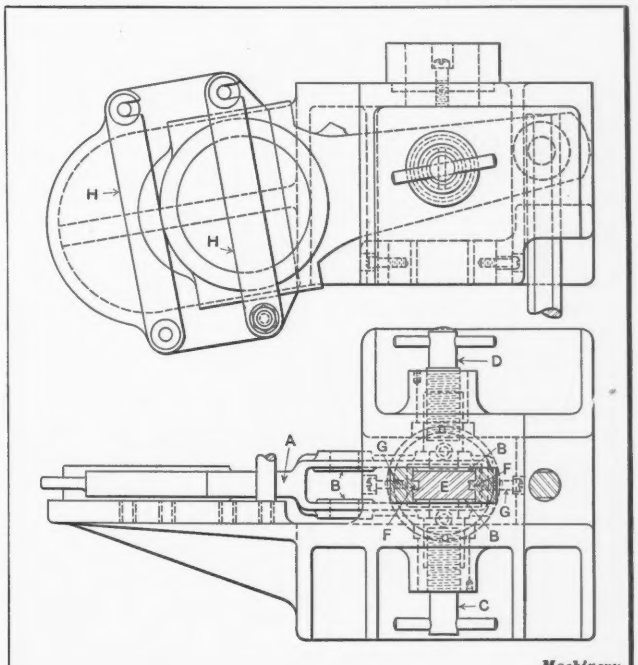


Fig. 16. Finishing the Inside Surfaces of Bosses B on the Broaching Machine

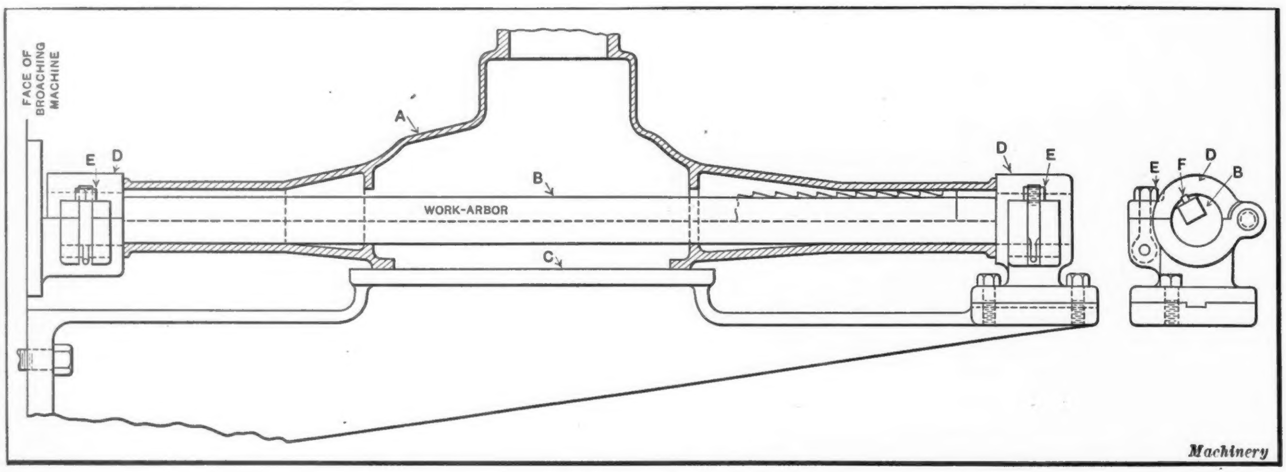


Fig. 17. Reo Rear Axle Housing A is held by Arbor B on Fixture C while broaching a Keyway

ture is secured to the faceplate on the machine by means of a boss *I* that enters a hole in the faceplate.

Broaching Inner Faces of Bosses on Eccentric Straps

Another application of a broaching machine for the performance of what might ordinarily be regarded as a milling operation is illustrated in Fig. 16, which shows the work-holding fixture for use on a J. N. Lapointe machine used for broaching the inner surface of bosses on eccentric straps. Referring to this illustration it will be seen that the work is shown at *A* and that there are two pairs of bosses *B*, the faces of which have to be broached. Two settings of the work are required to complete this job. Owing to the form of the work it is of particular importance to afford a means of support which will adequately prevent the surfaces to be broached from springing away from the tool. On the fixture for handling this job, such provision was made by means of two heavy screws *C* and *D*. With the work in place in the fixture, screw *C* is first turned until its end engages the under side of the work; then screw *D* is tightened down on the upper surface. In this way two thrust members are applied to opposite sides of the bosses from those which are to be broached, and there is no possibility of the pressure of the cut causing the work to spring out of place.

The broach is shown at *E*, and there is a guide member *F* at each side of the broach, which is held in the desired position by a screw *G*. After the first pair of bosses has been broached, the work is released and reset in the fixture to bring the second pair of bosses into the operating position. Aside from the location of the work, the method of broaching is identical in each case. So far as clamping the work in the fixture is concerned, this is quite simply accomplished by means of two clamping bars *H*, which are pivoted at one end, and provided with C-shaped latches at the other, which makes it necessary only to slightly loosen the binding nuts in order to allow the latches to be swung back to lift the work out of the fixture. The fixture itself is secured in the faceplate of the broaching machine by the familiar method of having a boss on the fixture enter a hole in the faceplate. On this job the work is cast steel, and ten eccentric straps are completely broached per hour.

Broaching Keyways in Reo Rear Axle Housings

Rear axle housings which have to be machined at the plant of the Reo Motor Car Co., Lansing, Mich., require a keyway to be cut that extends the entire length of the work. A broaching machine is used for this job, and Fig. 17 illustrates the work, work-holding fixture, and broach that are

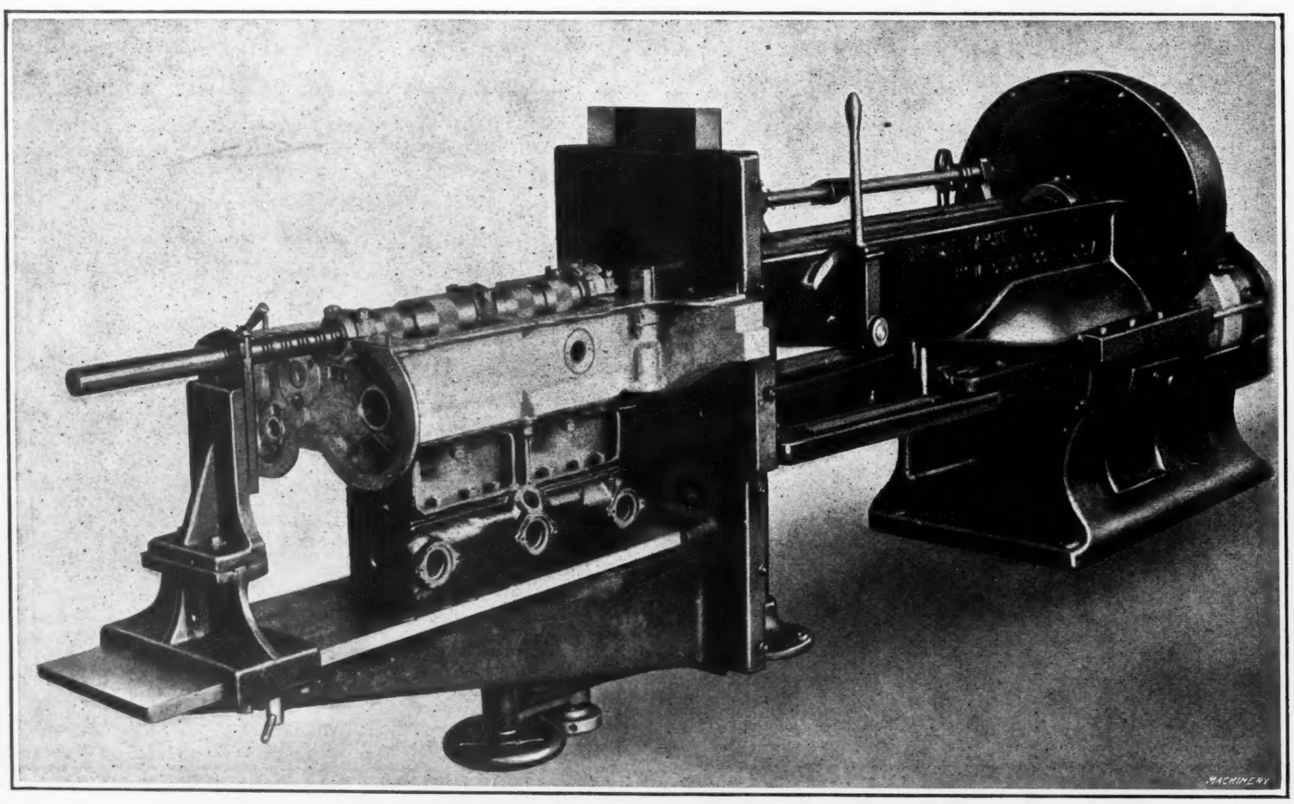


Fig. 18. Machine equipped for broaching the Camshaft Bearings in the Crankcase of a Motor Car Engine

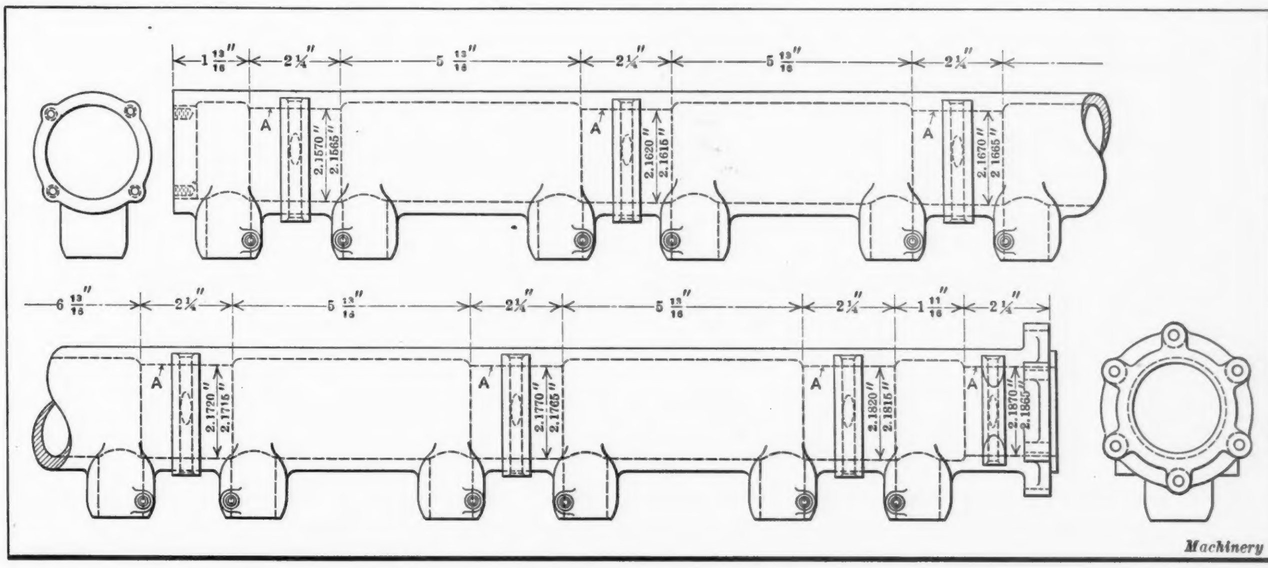


Fig. 19. Cam Frame of a Murray & Tregurtha Engine in which Seven Bearings A are finished by broaching

used. The rear axle housing *A* is shown in cross-section, and it will be apparent that a work-supporting arbor *B* is utilized to assist in holding the piece on the platen *C* of the fixture. In loading the fixture, the work *A* is first put into place on platen *C* after which the arbor *B* is slipped through the end brackets *D* and the hole in the work, and secured in place by tightening the binding nuts *E*. Reference to the end view of the fixture will make it apparent that arbor *B* is provided with a guide slot to receive broach *F*. On this job the rate of production is twelve housings per hour.

Broaching the Bearings in a Camshaft Case

Fig. 19 illustrates the camshaft case of an engine built by the Murray & Tregurtha Co., Boston, Mass., this illustration showing the work divided at the center and the two halves placed one beneath the other. Reference to the illustration will make it apparent that there are seven bearings *A* to be broached, the diameters of which range from 2.1570 to 2.1870 inches, each adjacent bearing being 0.005 inch larger than the preceding one. Quite obviously this difference in the size of the bearings introduces a complication in broaching, because of the impossibility of pulling a single broach right through the work. The very small difference in size between bearings that are located adjacent to each other makes it a profitable procedure to first broach all of the bearings to a standard size equal to that of the smallest bearing to be broached, namely 2.157 inches. After this has been done, a broach with a pilot 2.157 inches in diameter is used to broach all of the bearings except the one at the left-hand end of the work. The pilot on this broach enters the left-hand bearing which has already been finished to the desired size, and the teeth of this broach are so located that they come into engagement with the last of the bearings that they are to broach immediately after the pilot has entered the finished bearing at the left-hand end. When the second bearing has been broached in this way, a broach is used for finishing the third bearing from the left-hand end of the work, which has a pilot 2.162 inches in diameter. Similarly, the broaches for finishing the remaining bearings have pilots 2.167, 2.172, 2.177 and 2.182 inches in diameter, respectively.

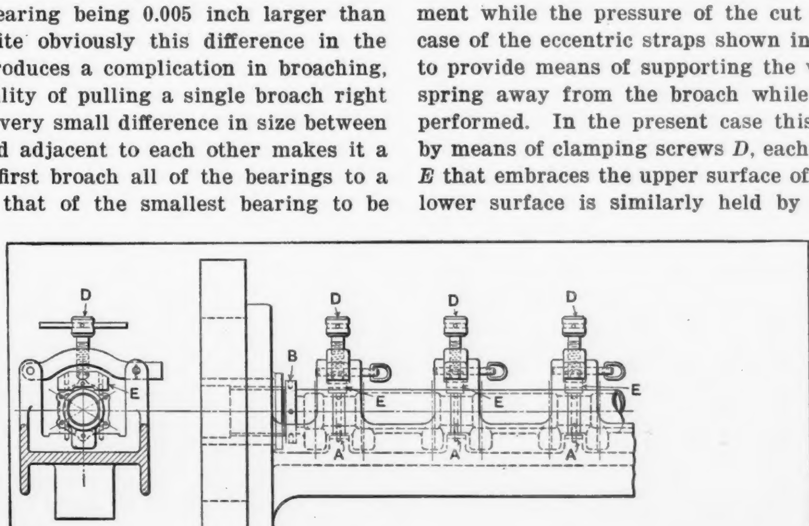


Fig. 20. Work-holding Fixture used on the Broaching Machine for finishing Bearings of the Cam Frame shown in Fig. 19

Fig. 20 illustrates the work-holding fixture that is utilized to support the camshaft case shown in Fig. 19, while the bearings are being broached. In a general way, this fixture is quite similar to the one described for use in cutting the keyway in Reo rear axle housings, except that no work-holding arbor is employed. Located at the top of each bearing there is an oil-hole, and with the work in the inverted position which it occupies in the fixture, a pin *A* enters each of these oil-holes to locate the work in the desired longitudinal position. After this result has been accomplished, two threaded collars *B* and *C* are tightened up to engage opposite ends of the camshaft case and prevent longitudinal movement while the pressure of the cut is effective. As in the case of the eccentric straps shown in Fig. 16, it is necessary to provide means of supporting the work so that it will not spring away from the broach while the operation is being performed. In the present case this result is accomplished by means of clamping screws *D*, each of which carries a yoke *E* that embraces the upper surface of each bearing, while the lower surface is similarly held by its seat in the fixture. With the work secured in this way, there is very little chance for the amount of pressure developed by the broach to cause it to expand sufficiently to introduce a serious error. On this job the material to be broached is lynite, and the rate of production attained is four completely broached camshaft cases per hour.

Suggestions for Overcoming Broaching Troubles

In setting up a broaching machine for cutting any shape of hole, care should be taken to ascertain

that the center of the pull bushing or broach holder is in line with the center of the faceplate hole. If the broach holder is slightly above or below the proper position, it will cock the work out of place, and even if the broach is not broken, the hole cut by it will not be perpendicular to the sides of the work. Should it happen that trouble is experienced through tearing the material, or that there is a tendency for the metal to break out around the end of the hole adjacent to the faceplate of the broaching machine, either of the following remedies may be applied; namely, the metal may be heat-treated to bring it to a scleroscope hardness of from 30 to 35. In some cases this trouble can be eliminated by grinding a 10- to 15-degree rake on the face of the broach teeth or by backing the metal up with a 1/4-inch collar between the work and faceplate, so that this collar will be broached out to the shape of the finished hole. For broaching bronze or other non-ferrous metals, a straight-faced tooth with about 1/2-degree top clearance will usually be found to give the most satisfactory results. In broaching square or hexagonal holes, if the broach tends to drift to one side owing to lack of provision for grinding it, two or three very light lengthwise rubs of an oilstone on the side of the broach teeth which cut fastest, will often remove the cause of trouble. As in other methods of machining, accidents are bound to occur in the performance of broaching operations; and if one or two teeth of a broach are broken, stoning or restepping the following two or three teeth will put the tool in good condition for subsequent use. In shops where broaching machines have been recently adopted and only a limited amount of experience has been obtained in their use, careful attention paid to the preceding recommendations will often be the means of substantially improving the rates of production and the quality of workmanship attained.

* * *

MILLING DOVETAIL SLOTS IN ARMATURE SPIDERS

The accompanying illustration Fig. 1 shows a No. 5 Cincinnati milling machine of the column and knee type, which is equipped with a special cross-rail attached to the over-arm, on which two special cutter-heads are mounted. The opera-

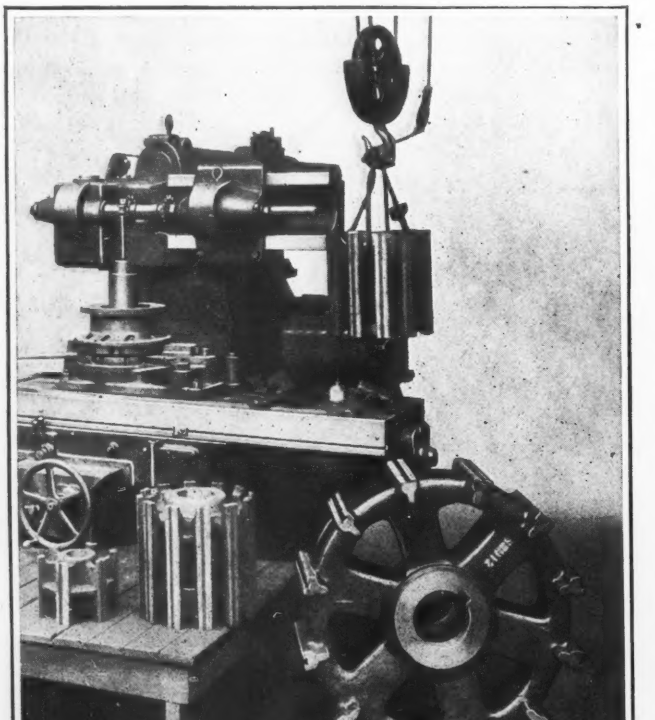


Fig. 1. Milling Machine equipped with Special Cutter-heads for milling Dovetail Slots in Armature Spiders

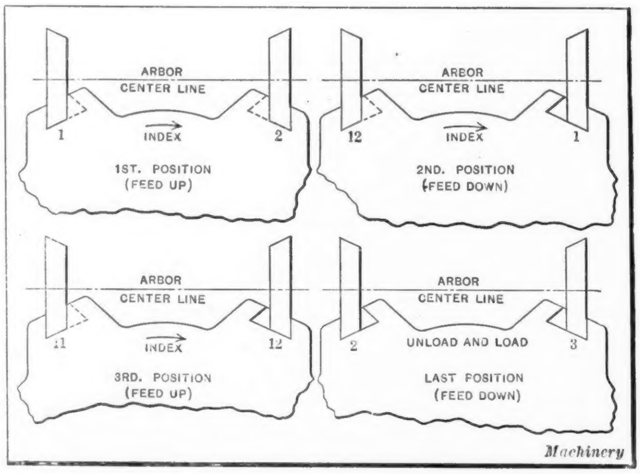


Fig. 2. Diagrammatic View of Sequence of Cuts taken in milling the Dovetail Slots in Armature Spiders

tion upon which this machine is employed is that of milling the dovetail slots in armature spiders for electric motors. The work is being done in the General Electric Co.'s shop at Schenectady, N. Y. The cutter-heads are adjustably mounted on the special cross-rail so that various sizes of spiders can be machined by setting the heads to accommodate the spacing of the lugs in which the slots are milled. The fixture upon which the work is mounted consists of a cast-iron base with a center post which fits the bore of the spider. Suitable means are provided for indexing and locking the fixture in position after taking each cut.

The work is swung from the floor to the machine table by means of a hoist as may be clearly seen in Fig. 1, which also shows a number of spiders of various sizes. Castings ranging from 9 1/2 to 33 inches in diameter are handled on the milling machine shown, equipped with fixtures of this type. The spiders that are machined on the fixture illustrated require twelve slots, each 10 1/4 inches long, extending the entire length of the casting. When the slots in the spider have been completely machined, the table is in the low position as shown in the illustration, so that when a new casting is mounted, the first two cuts will be taken on the upward travel of the table. The cutters employed are single-angle cutters and are so set in relation to the lugs on the outside of the casting being milled, that the proper angle of the slots relative to the face of the lugs will be obtained.

At the completion of the upward traverse of the table, one-half a slot will be milled by each cutter; the fixture is then indexed to the next position, and the direction of feed reversed while the remaining half of one of the slots and the first half of the next slot are milled. The idea is diagrammatically shown in Fig. 2, in which the first three positions and the final position of the indexing fixture may be seen. A little thought will make it clear that the sequence of cuts, during which no interruption is caused by returning the table for starting each cut, enables the work to be machined with a minimum amount of lost time or motion. The procedure of traversing the table up and down without changing the direction of the cutter rotation, continues until the work is finished, there being as many traverses required to finish a casting as there are slots to be milled in it. It will be observed that this method of milling out the dovetailed slots is somewhat similar to that employed in milling straight-tooth clutches.

* * *

Consul Harry Campbell reports from Java that American machine tools are rapidly gaining in favor in that market. One of the largest and most successful machine shops in Soerabaya is completely equipped with modern American machine tools. It is announced that this concern has recently been awarded the contract for the iron and steel work of a new government railway terminal at Tandjong Priok, the port of Batavia. This speaks well for the Soerabaya shop, with its American equipment, in view of the competition of Batavia firms located much nearer the work.

Reducing the Labor Turnover

By WILLIAM A. ROCKENFIELD, General Manager, Baldwin Chain & Mfg. Co., Worcester, Mass.

In the present article Mr. Rockenfield deals with some of the questions involved in the reduction of labor turnover. He points out the importance of making some active efforts to educate industrial workers in regard to their relation to the industries in which they are employed and the relation of the industries to the community. He advocates a proper conception of the term "labor," and deals with some of the problems met with in the handling of both native and foreign-born workers. He discusses the subject of welfare work and paternalism, and points out how many difficulties can be avoided and harmony promoted if more careful attention is given to what at first may appear to be minor matters in labor management.

WHENEVER an employment manager rises to talk today, he speaks about the "labor turnover," the "human element," etc., as if he had made some new discovery or invented a new philosophy. As a matter of fact, there is nothing new about it. It is only that it is becoming more and more evident that managements have neglected the most valuable part of their equipment and allowed it to depreciate faster than need be. There is but one science necessary to deal with these problems—the science of common sense. Because a problem is a large one, it does not necessarily mean that it calls for the application of extraordinary treatment. However, there are a number of things that will improve the situation, some of which are simple and elementary in their nature even if difficult to achieve in practice.

Relation of Industrial Workers to the Industries

One of the most important things is the education of workmen in regard to their relation to the industries and the relation of the industries to the community. If it were possible to indicate clearly how through the chain of industrial enterprises we all work mainly to produce things that we each need in our daily life, much would be achieved. Men work in industries because they can produce more in that manner than by working individually. The industries work to produce goods for the community and the community, in turn, is composed of the men who work in the industries. So that, after all, the whole thing is a circle in which men supply work to supply their own needs and produce the things that they themselves require.

This education should preferably begin in the public schools where it should be made evident to the children that the one great fact upon which industry is built, and upon which it stands or falls, is reasonable profit and reasonable returns to those whose initiative have made the industry possible. An understanding of this on the part of the children would tend to prevent unreasonable demands in the future. Labor could even be trusted to set its own wage scale and help production efficiency, if men were taught early that they finally pay their own wages, and that "what the dollar will buy" is the real measure of its value, and that that value depends directly upon the amount that is produced for a dollar's worth of wages in goods for consumption.

It is a mistake to believe that skilled workmen could not understand many of the problems of the employer, provided these problems were clearly and openly laid before them. Skilled workmen do not want revolution. At most, they want a little faster evolution.

A Broad Conception of the Word "Labor" is Needed

Many of the misunderstandings now arising between employers and employes are due to misapplication of the word "labor." Simple things are befogged and made hard to understand by employing unusual words and involved sentences. Such expressions as "the understanding of the psychology of labor" may look well in print, but mean little. In the first place, all effort, mental or physical, directed toward producing things that give happiness and comfort to life, is labor. To simply call physical effort "labor" is erroneous and creates the idea that "labor" is something to be disliked. On the other hand, if labor—work—is properly understood to include all useful effort, it acquires the dignity that is so much spoken of. If each of us were taught this simple principle in school, and if all of us would live up to this principle as well as preach it, it would aid a great deal in lessening the rift between capital and labor. If a man's value could be measured by his contribution to the world's useful work, it would probably be found that a first-class laborer contributes more to the community than the average clerk, even though the latter has been taught to think that by our present code he is on a higher social rung. When employers and employes thoroughly appreciate these facts, there will be less antagonism, less friction, and consequently less labor turnover.

Monotonous Work as a Cause of Unrest

The monotonous character of much of the work in the modern industrial plant is one of the real underlying causes of unrest and uneasiness on the part of employes. When a man becomes so accustomed to a job that he can do it without mental effort, his mind is free to interest itself in something outside of his job. The obvious remedy for this state of affairs would be to change the jobs frequently; but this is difficult, if not impossible, to do in present factory organizations. Nevertheless, the management should attempt to create some condition that would add the required stimulus to the work, and this can often be done in various ways if the will to do it is there. One of the reasons why office workers do not strike nor affiliate with unions is that their minds are kept busy and the nature of their work is more interesting, requiring more exercise of their mental faculties. The man who is placed where his work becomes too monotonous naturally will seek a change, and this is one of the causes of a large labor turnover. It is one of the most difficult causes to deal with, but the problem can doubtless be partially solved if executives will study the conditions of this problem as it appears in their particular plant.

Dealing with the Foreign-born Worker

Another problem in the question of labor turnover is the foreign-born worker. He ordinarily has no particular attachment to any plant or town, and it is more necessary to make him feel at home in the factory than in the case of a native-born American. Many schemes for Americanization have been put forward, but one fundamental fact stands out clearly, and yet it is the one most frequently overlooked. The most direct and the easiest way in which to make an American out of a foreigner is to "treat him like one."

In addition to this, there are a few minor rules that ought to be observed. Do not segregate foreign-born workers into groups of one nationality and language, as this does not promote their desire to learn English. Mix them with other nationalities, especially with Americans. This prevents undesirable race characteristics from cropping out and bearing fruit, and it destroys the opportunity for the unscrupu-

lous foreign language agitator to give to the foreign-born worker distorted views and ideas of the management.

Welfare Work and Paternalism

Much has been done to reduce the labor turnover by means of welfare work, and within limits, much that has been done is commendable. But it should always be remembered that it is not paternalism but the treating of workers like human beings that is the key to efficiency. Most men resent paternal care and do not like to be "nursed." They want to develop themselves and feel fully capable of working out their own destiny. Many welfare workers have observed that in any scheme of welfare work in which the worker does not voluntarily make some part of the sacrifice, or contribute, at least partially, his time, money, or energy, the efforts of the management usually fail in their object. On the other hand, every man appreciates knowing that unselfish aid will be quietly given, without advice or strings attached, in case of misfortune or need.

First Impression in Hiring Men Reduces Labor Turnover

Labor turnover could be largely reduced if men were hired with greater care and given a good impression of the firm for which they come to work, from the beginning. Ordinarily, the man applying for a position is asked numerous questions as to where he worked before and why he left his last job, but little is told him about the conditions of the job which he is expected to take. The wise employment manager sells the job to the man in the same way as a good salesman sells a machine to a customer. He impresses the man with the good points of the firm for which he is going to work and of the advantages of the job that he is taking. He gives him the right impressions of the conditions, tells him fairly what he is to expect, the kind of conduct that will be expected from him, and the advancement that he, in turn, may expect if he meets the requirements. Personal interest is shown in his affairs from the beginning, with a view to creating a good impression. First impressions are usually lasting, and this point has proved valuable in reducing labor turnover. Any other methods employed are good, bad, or indifferent according to the account they take of the peculiarity of human nature. No device or system will ever take the place of common understanding and mutual respect, and any scheme which does not work toward these things is only a makeshift.

Dismissing Men

The wise manager never discharges a man when either of the two is angry. If matters do not adjust themselves within the following twenty-four hours, it is time enough to take the required steps in a calm and sensible manner.

The problem of the elderly man in the industry is considered a difficult one and yet, as long as he is in good health, it should not be so difficult after all. The fact that a man has worked for one concern for a great many years is assurance of his loyalty and staying qualities. His loyalty and the example that he sets are worth a great deal to a business, and it is generally possible to find the kind of job that will meet the requirements, as he becomes older, both as regards his working ability and his personal pride. The knowledge that these men have of the factory and its traditions and the thousand and one things that one can learn only by years of experience in the same place, fit them for many positions which a younger man without this experience would not be so well able to fill.

Attitude toward the Labor Movement

In a properly managed factory, the attitude toward the labor movement is really of secondary importance. If the management does not believe in collective bargaining, it will never let any conditions come to that stage. Men do not resort to collective methods until they find it impossible to get satisfaction individually. The collective method really is against the natural inclinations of most men. This is the reason why cooperative stores and similar enterprises have never succeeded in the United States to any appreciable extent, and they never will unless the consumer is absolutely forced into cooperative buying through the coercion of profiteering on the part of wholesalers and retailers. In the same way, discontent and strikes are stopped before they start in factories where the individual workman knows that he will receive consideration and fair treatment upon individual application.

The Labor Turnover Record

In studying the question of labor turnover in connection with production, the monthly production record should contain, in addition to the figures stating output, cost, labor turnover, etc., such information as the number of men injured, and the reasons for the injuries; the number of men sick, and the reasons why. By a careful study of questions of this kind it is often possible to remove some of the reasons for a high labor turnover that may not previously have been suspected. As a rule, the manager must entrust many of the mechanical details to subordinates, but he cannot afford to entrust facts relating to the human side to minor executives. The human factor pays the largest dividend and contributes most largely to the efficiency of the plant. That is the part of the machinery to which he must give his first and most careful attention.

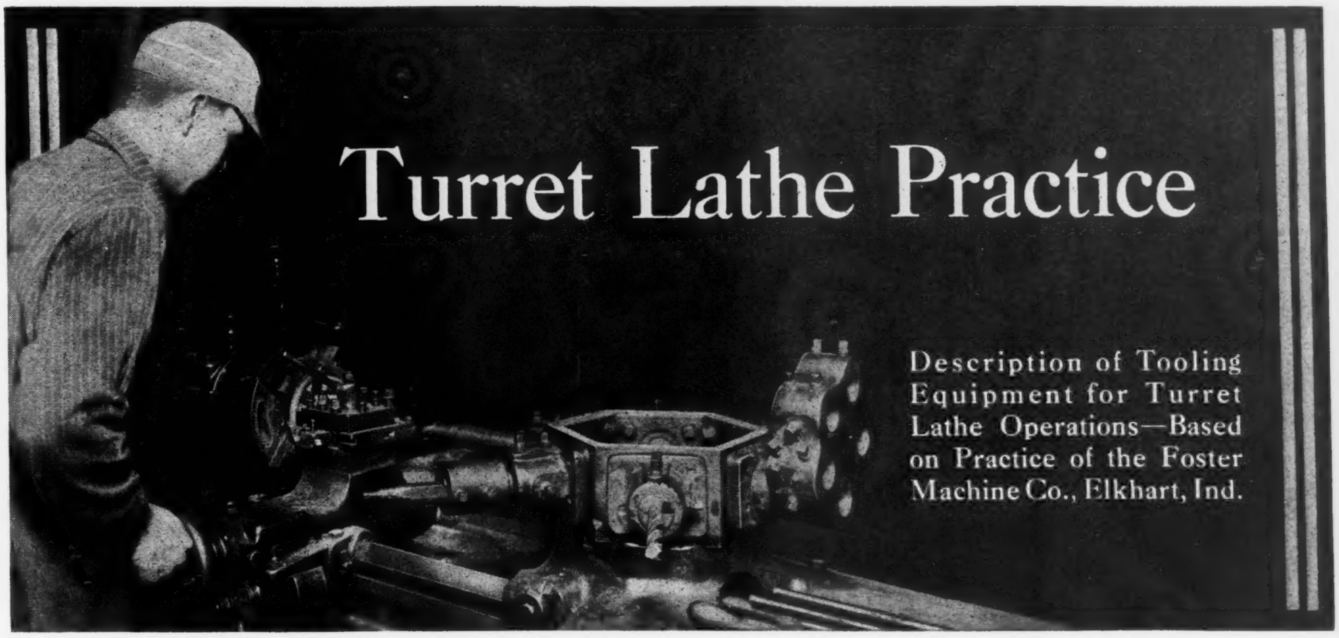
In conclusion, my experience has been that too strict a manager cannot obtain any more cooperation than too easy a one—neither extreme produces harmony nor creates the conditions under which efficiency and production are the result. Men with initiative do not seem to be able to adjust themselves properly to either kind of manager. The best means for securing the cooperation of employes is expressed in the old saying, "If you want a friend, be one." You will get out of your plant just exactly what you put into it. If you put into your plant confidence, fairness, and loyalty, you will find in time, that these same qualities will return to you through your employes.

* * *

THERMOMETER SYSTEM FOR PREVENTING SPONTANEOUS COMBUSTION

It is necessary for large industrial plants, railroads, etc., to store immense quantities of coal, which is often a serious and expensive problem. The great danger resulting from the storing of coal is the slow combustion which takes place and which is not detected until the odor becomes noticeable. When this happens, the coal should be redistributed so as to remove pressure on the heated layer, and in some cases the entire coal pile must be turned over, requiring quick action and resulting in great expense.

In order to detect any increase of temperature in the coal pile of one large plant, an electrical thermometer system was installed having the temperature indicating instrument or pyrometer in the engineer's office. The switches were so arranged that the temperature of predetermined locations in the coal pile could be obtained, and coal could then be removed from necessary points. A temperature of 250 degrees F. was considered to be the safe internal temperature. Portable receptacles for thermo-couples were placed in rows in the pile. These receptacles were constructed of 1-inch wrought-iron pipe, welded to a point at the end which entered the coal pile. The exposed end was fitted with a self-closing cap to prevent the entrance of anything that would interfere with the insertion of the thermo-couples. The wiring to the engineer's office was of a permanent nature from a central location of the coal pile and from this point lines radiated to the thermo-couples. The thermo-couple receptacles were numbered, and each row had a distinguishing letter. The switches in the engineer's office were numbered and lettered in a manner to correspond with these receptacles. This plan permitted the thermo-couples to be placed in the desired receptacles and the engineer to observe the temperature readings of the coal at the different points, and thus detect dangerous increases of temperature.



Turret Lathe Practice

Description of Tooling Equipment for Turret Lathe Operations—Based on Practice of the Foster Machine Co., Elkhart, Ind.

IN the first installment of this article, published in the June number of MACHINERY, tooling equipments required for finishing gear blanks, friction cones, and automobile pistons were dealt with. The present article, which is the second and last installment, describes tooling equipments employed on turret lathes for machining automobile differential gear cases, chuck bodies, semi-steel castings, friction pulleys, and bar stock parts.

Finishing Automobile Differential Gear Cases

The differential gear case illustrated in Fig. 16 is machined on a No. 1-B universal turret lathe as indicated by the heavy lines. This part is made of malleable iron and is machined in 6.4 minutes. A machine equipped for the performance of this operation is shown in Figs. 18 and 19, from which a good idea of the set-up may be obtained. Fig. 18 shows a view of the front of the machine, while Fig. 19 presents a close-up view of the work and some of the tools, this photograph being taken from the rear of the machine. The various steps in the operation are as follows: (1) The casting is placed in a three-jaw air chuck provided with special jaws that grip the work along the periphery of the flange. The chuck is also provided with a guiding bushing to suit the pilots of the various tools mounted in the turret. (2) Holes *A*, Fig. 16, are rough-bored and surface *B* is turned by the tools held in a double-cutter piloted boring-bar mounted in a turning slide tool in the turret; surface *C* is rough-turned by a tool held in the square turret, and surface *D* is rough-faced by another tool held in the square turret. (3) Holes *A* are finish-bored and surface *E* is faced by a double-cutter piloted boring-bar held in a turning slide tool mounted in the turret. (4) Surface *F* is rough-faced by a tool mounted in a piloted bar which is held in the turret. (5) Surface *F* is finish-faced by a tool mounted in another piloted bar, which is also held in the turret. (6) Holes *A* are reamed by an expansion reamer mounted in the turret.

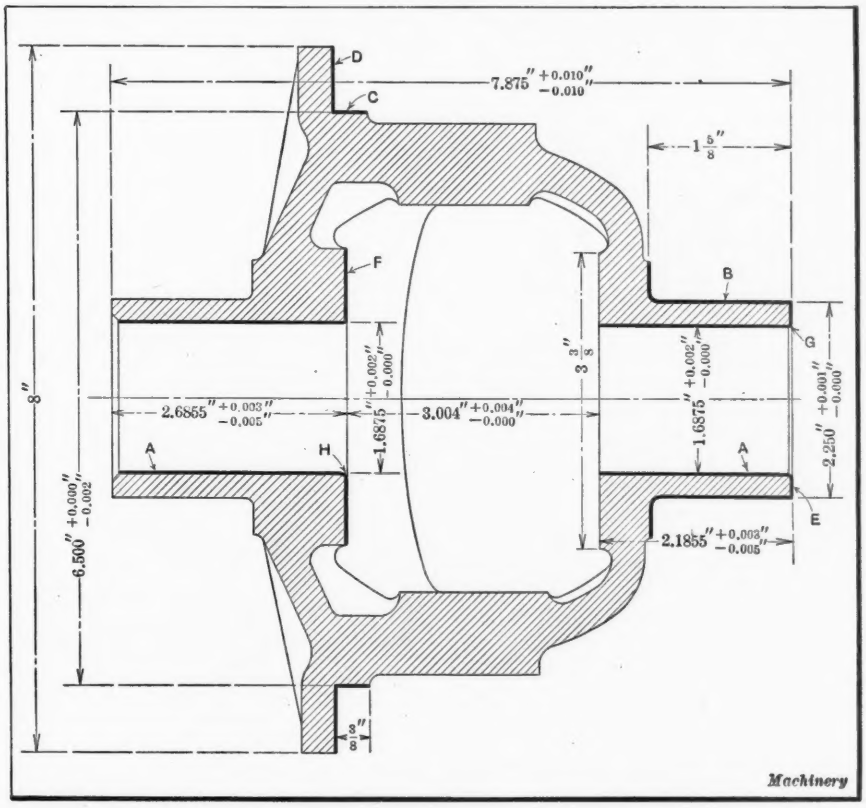


Fig. 16. Drawing of Automobile Differential Gear Case

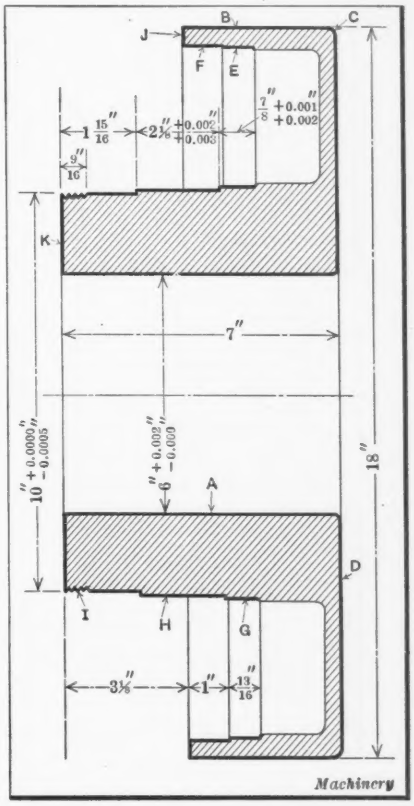


Fig. 17. Cast-steel Chuck Body

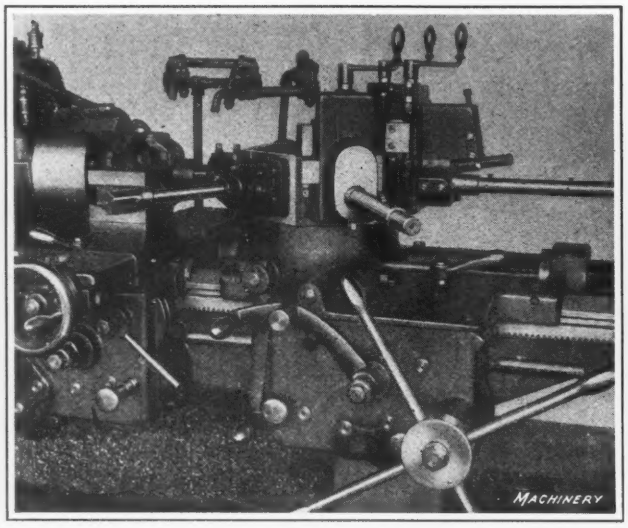


Fig. 18. Machine equipped with Tools required in finishing the Differential Gear Case

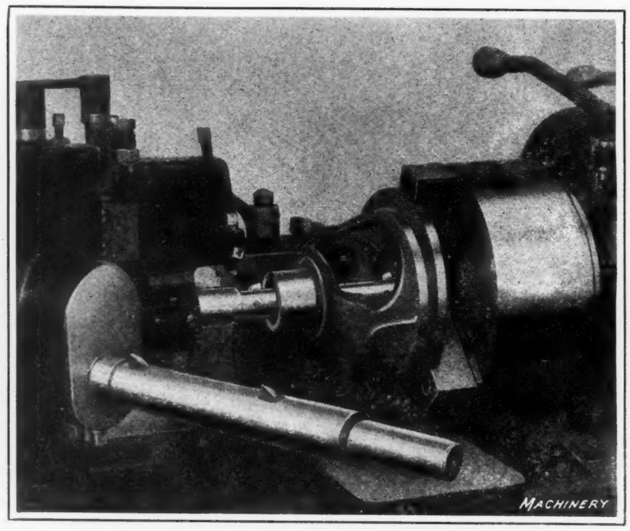


Fig. 19. Rear of Machine illustrated in Fig. 18, showing a Close View of the Work

(7) Chamfer *G* is formed and corner *H* is rounded by tools mounted in a piloted bar held in a sliding tool in the turret. (8) The casting is removed from the machine. This completes the operations on the differential gear case.

Equipments Used in Machining Cast-steel Chuck Bodies

The cast-steel chuck body illustrated in Fig. 17 is machined in two operations as indicated by the heavy lines, in 1 hour 21.8 minutes on No. 3-B universal turret lathes. A

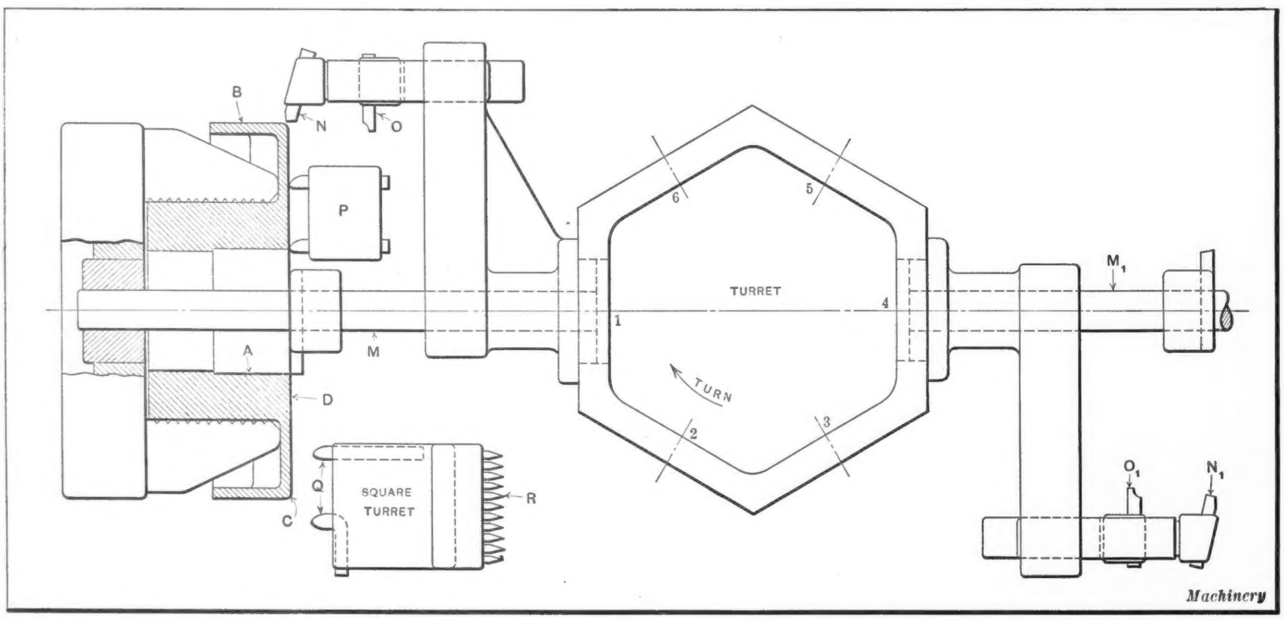


Fig. 20. Equipment used in the First Operation on the Chuck Body shown in Fig. 17

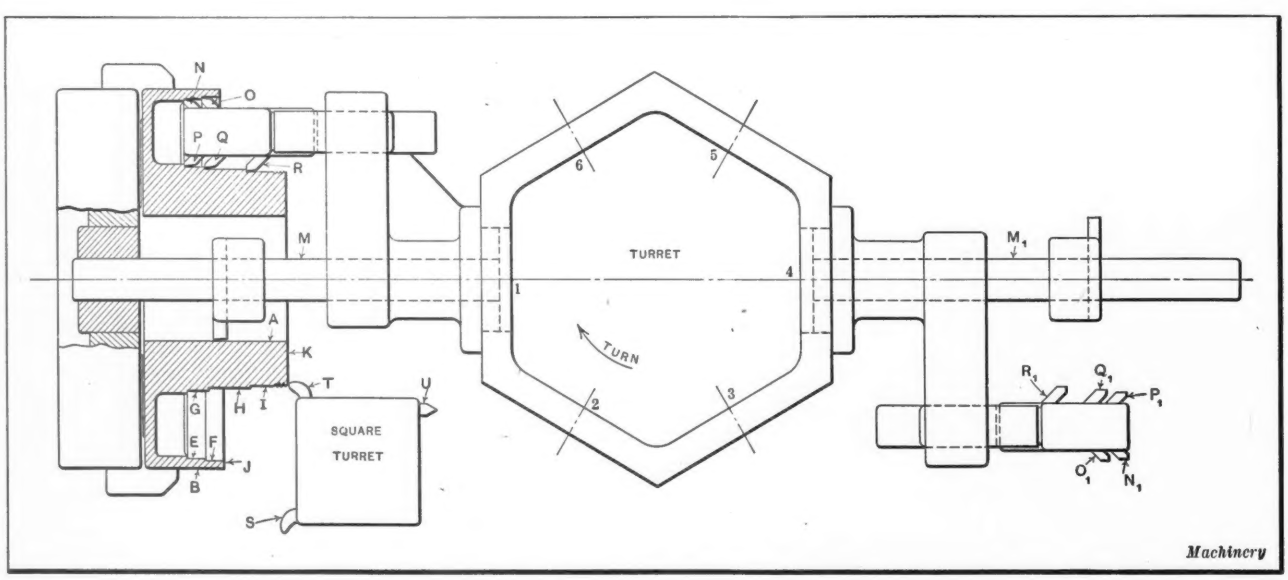


Fig. 21. Lay-out of the Tools used in the Final Operation on the Chuck Body

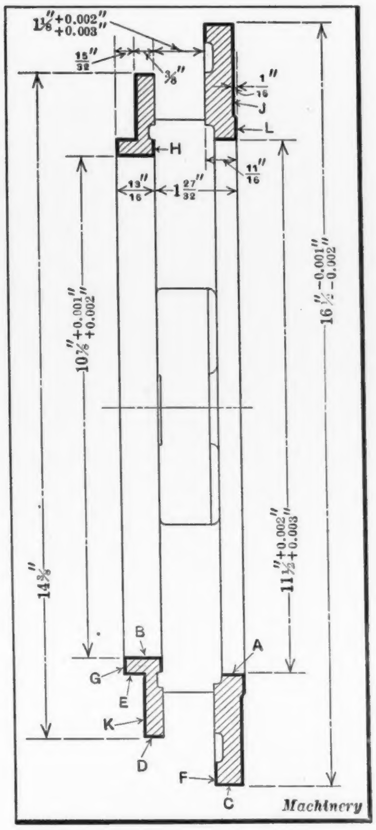


Fig. 22. Semi-steel Casting

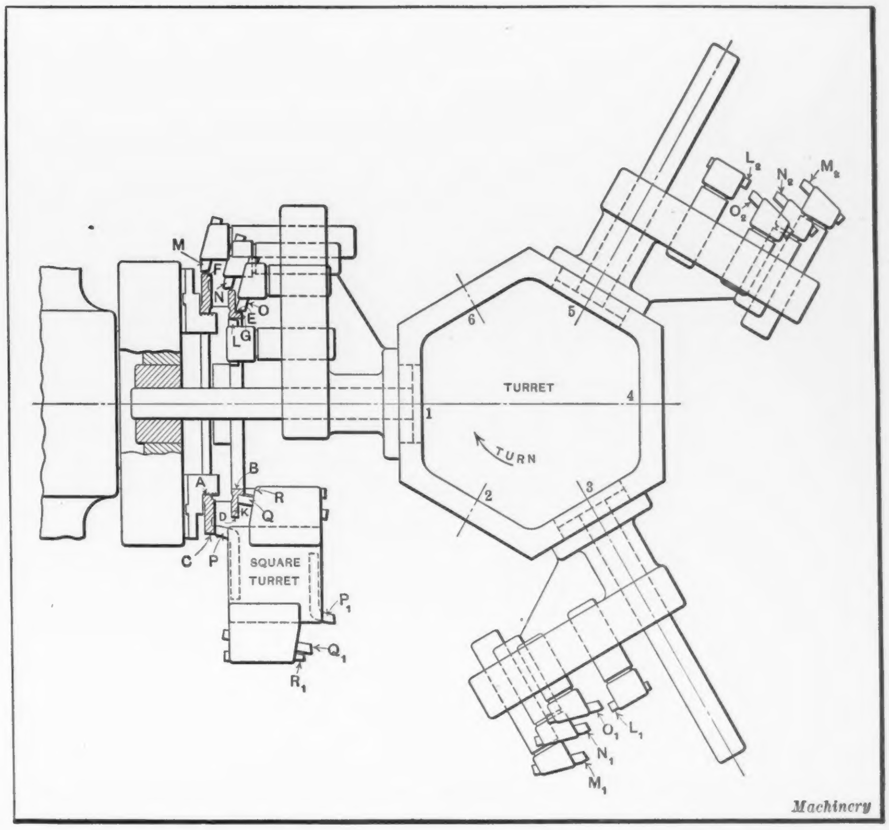


Fig. 23. Tool Lay-out used in the First Operation on the Casting illustrated in Fig. 22

lay-out of the tooling equipment used in the first operation is shown in Fig. 20; this operation requires 42.2 minutes. The series of steps is taken in the following order: (1) The work is mounted on a chuck equipped with three corrugated and hardened jaws that grip it on the rough surface of the hub. (2) One-half the length of hole *A* is rough-bored by the cutter held in the piloted boring-bar *M*; surface *B* is rough-turned by tool *N*, and corner *C* is rough-turned by tool *O*, these tools and boring-bars being held in the multiple turning head in Side 1 of the turret. Surface *D* is rough-faced by the tools in toolpost *P* on the rear of the cross-slide. (3) The part of hole *A* rough-bored in the second step is now finish-bored by the cutter held in boring-bar M_1; surface *B* is finish-turned by tool N_1, and corner *C* is finish-formed by tool O_1, these tools and the boring-bar being mounted in the multiple turning head in Side 4 of the turret. At the same time, surface *D* is finish-faced by tools *Q* which are held in the square turret. (4) Concentric grooves are cut on surface *D* by tools *R* which are mounted in the square turret. (5) The casting is removed from the chuck, completing the operation.

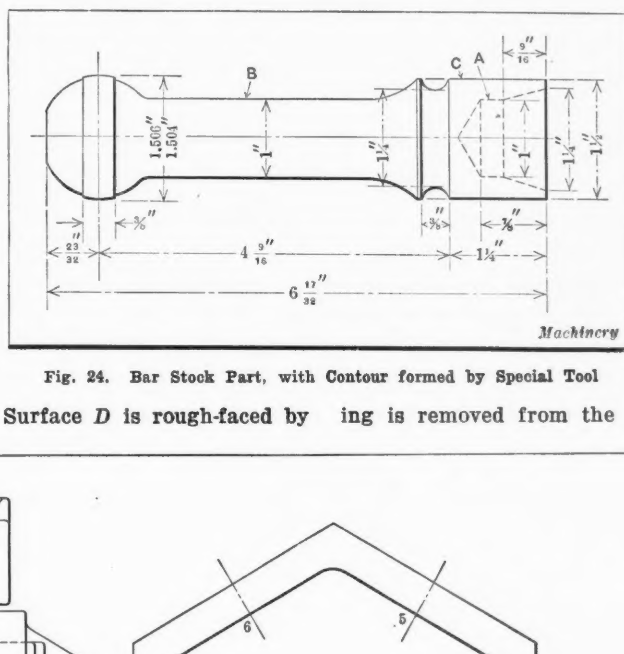


Fig. 24. Bar Stock Part, with Contour formed by Special Tool

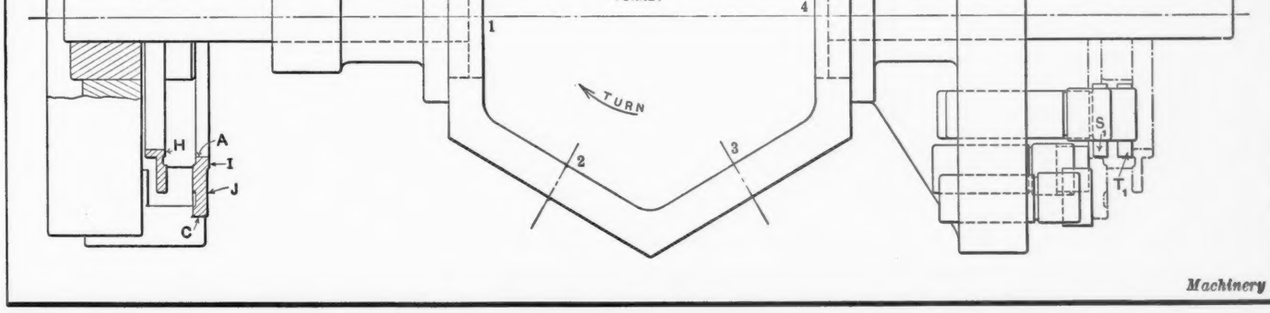


Fig. 25. Tooling Equipment required in the Second Operation on the Part shown in Fig. 22

The second operation on the chuck body is performed in 39.6 minutes. A lay-out of the tooling equipment used in this operation is shown in Fig. 21. The successive steps are as follows: (1) The work is mounted in a three-jaw chuck which grips it on the previously finished surface B. (2) The half of hole A that is still unfinished is rough-bored by the cutter held in boring-bar M; surface E is rough-bored by tool N, surface F is rough-bored by tool O, surface G is rough-turned by tool P, surface H is rough-turned by tool Q, and surface I is rough-turned by tool R, all of these tools and boring-bar M being mounted in the multiple turning head in Side 1 of the turret. At the same time surfaces K and J are rough-faced by tool S, which is held in the square turret. (3) The portion of hole A rough-bored in the preceding step is now finish-bored by the cutter held in the piloted boring-bar M_1. Surface E is finish-bored by tool N_1, surface F is finish-bored by tool O_1, surface G is finish-turned by tool P_1, surface H is finish-turned by tool Q_1, and surface I is finish-turned by tool R_1, all of these tools and boring-bar M_1 being held in the multiple turning head mounted in Side 4 of the turret. At the same time, surfaces K and J are finish-faced by tool T, which is held in the square turret. (4) The threads on surface I are cut by tool U mounted in the square turret, which is used in conjunction with the screw-cutting attachment. (5) The finished part is removed from the chuck.

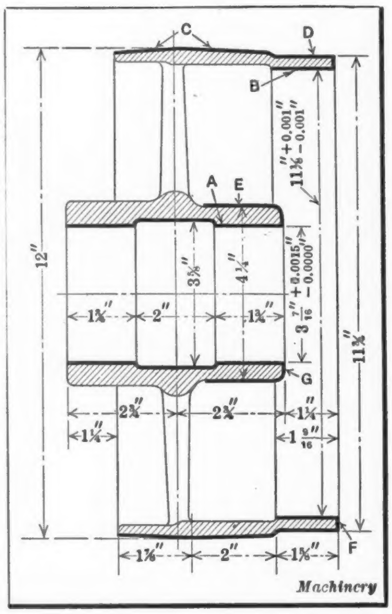


Fig. 26. Drawing of Friction Pulley

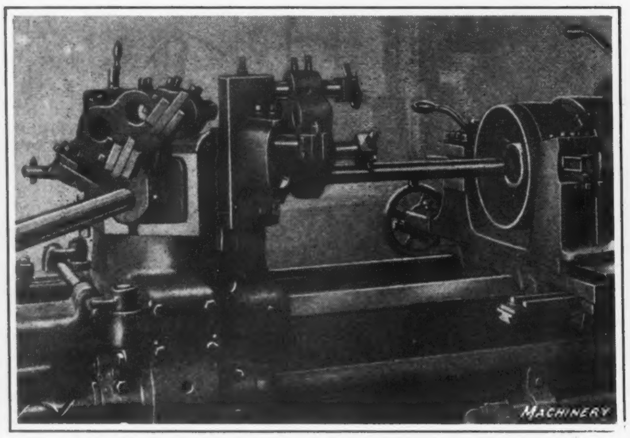


Fig. 27. Machine engaged in finishing the Friction Pulley illustrated in Fig. 26

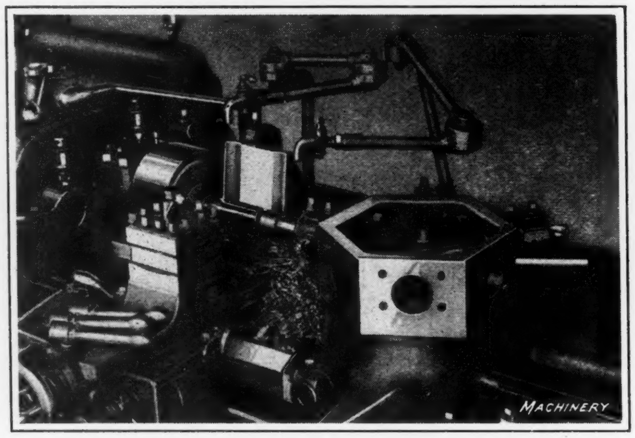


Fig. 28. Machine Set-up employed in manufacturing Part shown in Fig. 24

Tooling Equipment Employed in Machining Semi-steel Casting

Fig. 22 shows a semi-steel casting which is machined in two operations on No. 3-B universal turret lathes. Both operations are performed in 16.5 minutes. A lay-out of the tooling equipment used in the first operation is illustrated in Fig. 23. The sequence of the various steps is as follows: (1) The work is placed in a three-jaw chuck equipped with corrugated and hardened false jaws that hold the work by bearing against hole A. (2) The hole B is rough-bored by tool L, the surface C is rough-turned by tool M, the surface D is rough-turned by tool N, and the surface E is rough-turned by tool O, all of these tools being mounted in the piloted multiple turning head held in Side 1 of the turret. At the same time surface F is rough-faced by tool P, surface K is rough-faced by tool Q, and surface G is rough-faced by tool R, these tools being held in the square turret. (3) Hole B is again bored by tool L_1, and surfaces C, D, and E are again turned by tools M_1, N_1, and O_1, respectively, all of these tools being mounted in the piloted multiple turning head in Side 3 of the turret. At the same time surface F is finish-faced by tool P_1, surface K is finish-faced by tool Q_1, and surface G is finish-faced by tool R_1, these tools being mounted in the square turret. (4) Hole B is finish-bored by tool L_2, and surfaces C, D, and E are finish-turned by tools M_2, N_2, and O_2, respectively, all of which are mounted in the turning head in Side 5 of the turret. (5) The casting is removed from the chuck.

The tooling equipment used in machining the remaining surfaces on the casting is shown in Fig. 25. This operation is completed in 6.6 minutes. The series of steps is as follows: (1) The work is mounted in a three-jaw chuck that grips it along the previously finished surface C. (2) Hole A is rough-bored by tool S, and surface H is rough-faced by tool T, these tools being mounted in the piloted multiple turning head held in Side 1 of the turret. The surfaces J and I are rough-faced at the same time by tools U and V, which are mounted on a tool-block on the rear of the cross-slide. (3) Hole A is finish-bored by tool S_1, and surface H is finish-faced by tool T_1, these tools being mounted on the piloted multiple turning head held in Side 4 of the turret. The work is indicated on this head by dot-and-dash lines. (4) The finished casting is removed from the machine.

Machining Operations on Friction Pulleys

The cast-iron friction pulley shown in Fig. 26 is machined in one operation on a No. 2-B universal turret lathe. A machine provided with the tooling equipment used in machining

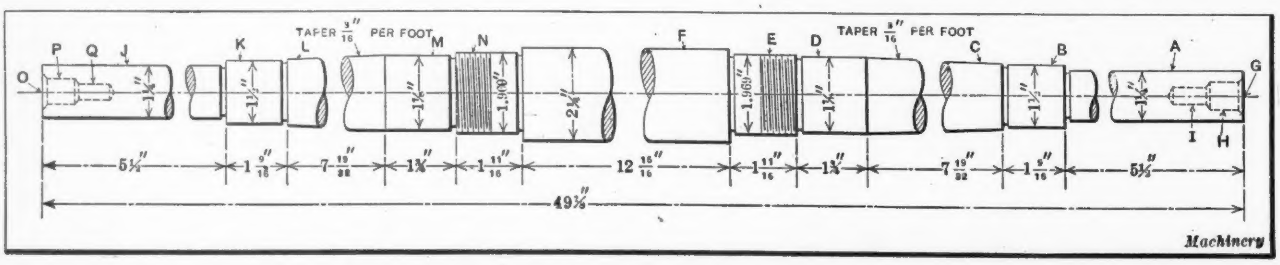


Fig. 29. Long Steel Spindle machined from Bar Stock on No. 2-B Universal Turret Lathes

this piece is shown in Fig. 27. This illustration shows the rear of the machine, and the photograph was taken after the pulley mounted on the lathe had been partially machined. The series of steps in this operation is taken in the following order: (1) The pulley is placed in a three-jaw Barker chuck, equipped with special jaws that bear against the inside of the pulley rim. This chuck is also provided with a guiding bushing to suit the pilots on the various tools mounted in the turret. (2) Hole *A* and surface *B*, Fig. 26, are rough-bored, and surfaces *C*, *D*, and *E* are rough-turned by tools mounted in a multiple turning head which is held in the turret, while surfaces *F* and *G* are rough-faced by tools mounted in the square turret. (3) Hole *A* and surface *B* are finish-bored and surface *D* is finish-bored by tools mounted in a multiple turning head held in the turret, while crown *C* is finish-turned by a tool held in the square turret and a tool mounted on a tool-holder on the rear of the cross-slide, these tools being operated in conjunction with a taper attachment on the rear of the lathe. (4) The relief in hole *A* is bored by a cutter held in a boring-bar which is mounted in a sliding tool attached to the turret. (5) Hole *A* and surface *B* are reamed by a special combination expansion reamer mounted in the turret. (6) The finished pulley is removed from the lathe.

Producing a Part from Bar Stock

Fig. 24 shows the drawing of a part machined from bar stock in one operation on a No. 1-B universal turret lathe. A machine engaged in producing one of these pieces is shown in Fig. 28. This illustration shows quite clearly the method employed in the manufacture of this part. The steps in this operation are taken as follows: (1) The stock is fed to a stop on the turret and then held by means of an automatic chuck. (2) Hole *A*, Fig. 24, is drilled by a drill mounted in a flanged tool-holder held in the turret. (3) Hole *A* is chamfered as shown, by means of a taper reamer mounted in a flanged tool-holder held in the turret. (4) Surface *B* is rough-turned by a tool held in the square turret. A revolving center which is mounted in the turret is placed in hole *A* during this and the succeeding operation so as to support the work adequately during these operations. (5) All the remaining unfinished surfaces except surface *C* (which is not finished, the part being made from cold-rolled steel) and the surface produced when the piece is cut from the stock, are finish-formed by means of a special forming tool that is held in the rear tool-holder. (6) The completed piece is cut off from the stock by a tool held in the square turret.

Equipment Used in Machining a Long Steel Spindle

The steel spindle illustrated in Fig. 29 is machined in two chuckings on No. 2-B universal turret lathes. It will be noted that this piece is over 4 feet long, while the greatest diameter is only 2¼ inches. Both operations on this spindle are performed in 35.7 minutes. A lay-out of the tooling equipment used in the first operation is shown in Fig. 30, this operation being performed in 19.9 minutes. There are no reference letters shown on the various surfaces of the work in Fig. 30, and so Fig. 29 must be referred to in following the method of manufacturing this part. The various steps in the operation are taken in the following order: (1) The stock is fed up to the stop on the turret corner between Sides 1 and 6, which permits somewhat more than one-half of the length of the piece to project beyond the chuck. (2) Surfaces *A* and *B* are rough-turned by the tool held in the single cutter turner in Side 1 of the turret, and surfaces *C*, *D*, and *E* are rough-turned by tool *T*, which is held in the square turret. (3) Surfaces *A* and *D* are finish-turned and surface *C* is finish-straight-turned by the tools held in the multiple cutter turner in Side 2 of the turret. The work is indicated in this turning fixture by dot-and-dash lines. At the same time, surface *F* is turned by tool *T*. (4) Surfaces *B* and *E* are finish-turned by the tools held in the multiple cutter turner mounted in Side 3 of the turret. The work is also indicated in this fixture by dot-and-dash lines. (5) A center is drilled in end *G* by the roller-rest centering tool in Side 4 of the turret. Then the centering tool is replaced by

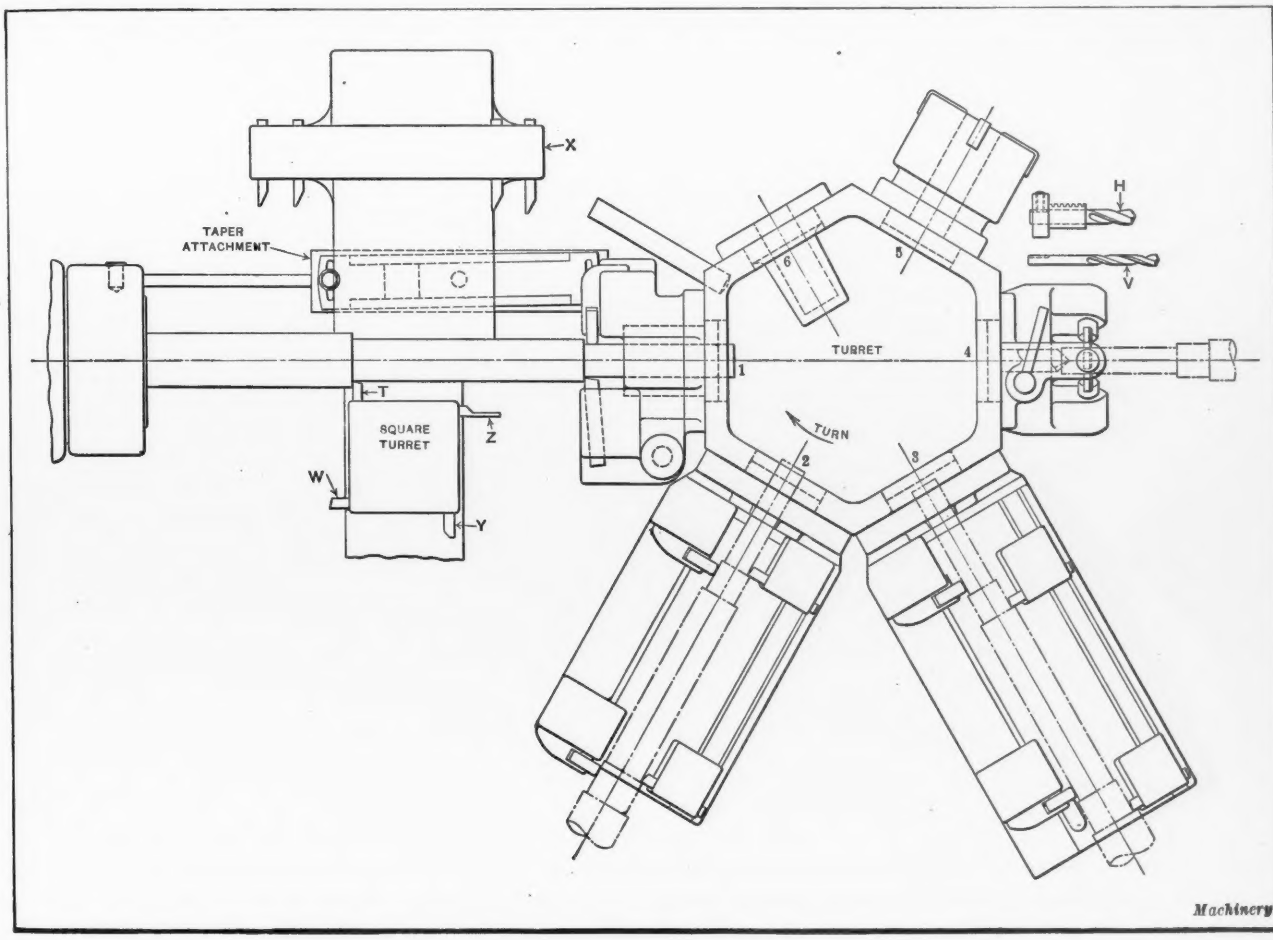


Fig. 30. Lay-out of Tooling Equipment used for machining the Steel Spindle illustrated in Fig. 29, in Two Chuckings

drill H and hole H is drilled, after which drill H is replaced by the tap drill V and hole I is drilled in preparation for a tapping operation which is performed in this end by hand. The centering tool is then replaced in the fixture. While the centering holes are being drilled, surface C is rough-taper-turned by tool W mounted in the square turret, which is used in conjunction with a taper attachment. (6) While end G of the shaft is still supported by the centering tool in Side 4 of the turret, the necking tools mounted on fixture X on the rear of the cross-slide are first located, and then the four grooves between the various surfaces on the right-hand end of the spindle are turned by these tools. (7) The threads on surface E are cut by the self-opening floating die-head mounted in Side 5 of the turret. (8) The stock is fed up to the special stop in Side 6 of the turret, which permits slightly more than the total length of the spindle to project beyond the chuck. (9) While the stock is supported in the stop just mentioned, the shaft is chamfered at end O by tool Y, which is held in the square turret, so that the single cutter turner which turns surface J in the succeeding operation can be properly started. (10) While the piece is still supported in the stop in Side 6 of the turret, the spindle is cut off from the stock by tool Z, which is also held in the square turret. The projecting end of the stock is chamfered at the same time by tool Z, so that the single cutter turner used to turn this end of the succeeding spindle can be correctly started.

The second operation on the spindle consists in machining the left-hand end, and is performed in 15.8 minutes. The work is held in a chuck equipped with a collet bushing that grips the work around the previously finished surface F. The tooling equipment used in the second operation is identical with that shown in Fig. 30, because surfaces J, K, L, M, and N and holes P and Q, respectively, are of the same dimensions as surfaces A, B, C, D, and E and holes H and I which were machined by means of this tooling equipment. The only difference between the two operations is the machining of surface F, which is performed in the first operation, and for this reason a detailed description of the steps in the second operation is not considered necessary.

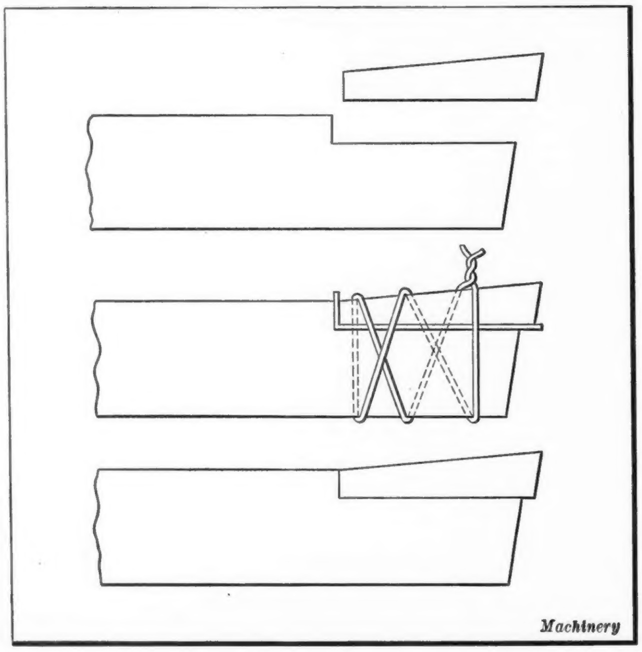
* * *

MAKING TIPPED TOOLS

Owing to the high prices which have been commanded by high-speed tool steel during the past few years, it has become a matter of more than ordinary importance to conserve the use of this material as far as possible. Even when low selling prices prevailed, the use of a tool-holder for supporting a piece of this high-priced steel in a shank made of less expensive metal fully demonstrated its practicability. However, a tool-holder is not applicable on some classes of work, and in cases where it would otherwise be necessary to employ a solid forged tool, very satisfactory results can be obtained by forging a shank from inexpensive machine steel and welding or brazing a cutting tip made of high-speed steel to this holder. The desirability of such a method of "tipping" a tool has been apparent for many years, but until recently difficulties were encountered in securing a firm union between the shank and high-speed steel tip by either welding or brazing.

Descriptions of welded tools have been published in previous numbers of MACHINERY, so that no further discussion of their features is required. The following explanation of the way in which toolmakers employed by the Nash Motors Co., Kenosha, Wis., proceed to braze high-speed steel or stellite cutting tips to low-carbon steel shanks will prove of interest. The method of procedure is to form the tool shank with a seat for the high-speed steel tip which is usually made of the required width and form at the front edge, and about 1/8 inch thick by 1/2 inch long in the case of medium sized tools. The tip is made to project out at the front and sides of its seat on the shank, so that it may be ground to the desired form after being brazed in place. The machine steel shank extends under or behind this piece of high-speed steel, so that plenty of support is provided for the thrust of the cut. A strip of thin brass or copper is next cut out, which is of the same width and length as the developed area of the under side and the back end of the high-speed steel tip, that is to say, the copper covers the area of the bottom and back of the tool steel that comes into contact with the seat cut into the machine steel shank. This copper is bent to conform to the seat and is put into place between the tip and the shank with a coating of borax to serve as a flux.

After this has been done, the tip is secured in place on its seat on the shank by twisting a piece of wire tightly around it, as shown in the illustration. The tool is then placed in a heating furnace, where it is left for a sufficient time to raise its temperature to about 2400 degrees F., the exact figure being determined by the proper quenching temperature for hardening the high-speed steel of which the tip is made; and as copper starts to melt at 1940 degrees F., the strip of copper placed between the two pieces of steel will have been brought into a fluid condition. When the desired temperature is attained, the tool is removed from the furnace and first struck a moderate blow with a hammer to force the high-speed steel tip down on its seat in the shank and distribute the brazing material uniformly over the joint. The tool is then plunged into a suitable quench-



Successive Steps in making a Tipped Tool

ing bath to harden the high-speed steel tip. At the same time the copper solidifies and effectually brazes the high-speed steel cutting tip to the machine shank, thus producing an efficient tool at a relatively low cost.

* * *

At a meeting of the executive board of the National Automobile Chamber of Commerce, held on March 3, 1920, the following resolution was adopted: "Whereas, efforts are being made to require by congressional legislation the use of the metric system of weights and measures in this country, and whereas, a canvass of motor car manufacturers, members of this organization, has failed to develop that any of them is in favor of such legislation, owing particularly to the difficulty at this time of changing dies, factory equipment, and mechanism and the great cost of same; also because of the confusion that would be created among workmen who have not been educated in the metric system, be it resolved, that this board is opposed to legislation making the use of the metric system of weights and measures obligatory, and recommends that members of the National Automobile Chamber of Commerce lend their support to the American Institute of Weights and Measures, which is actively opposing this movement."

CAST-IRON MOLDS FOR BAKELITE PRODUCTS

By LEONARD C. LOTZ

The expense connected with the manufacture of polished steels molds for producing bakelite or condensite articles has led to the frequent use of cast-iron molds in the production of many of these parts. When using molds of this type, satisfactory results will be obtained if the article is buffed after it leaves the mold. Some of the most common articles that can be successfully produced in cast-iron molds are screwdriver and knife handles, electrical insulators, surgical appliances, and various other similar articles. In the making of these cast-iron molds, plaster patterns are employed, the procedure being carried out in the following manner:

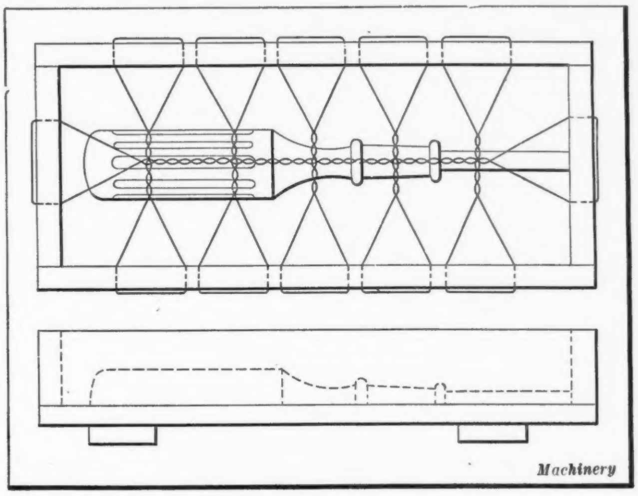


Fig. 1. Mold for producing Plaster Patterns

A split master wood pattern of the article is made, each half being fastened to a board, and a flask frame for holding the plaster built around each half of the pattern, as shown in Fig. 1. The frame, it will be noticed, is strengthened by reinforcing wires arranged as shown, the idea being to support the plaster and make a stronger cast. The plaster casts which are made from the wooden pattern when completed form the mold from which duplicate pattern models of plaster can be made. In using the wooden master pattern, Albany grease should be employed to prevent the pattern from sticking in the mold. The mold shown in Fig. 1 is used in the manner just described, for producing plaster patterns for a screwdriver handle. The frame should be well shellacked before pouring the plaster; otherwise, it will swell and twist out of shape.

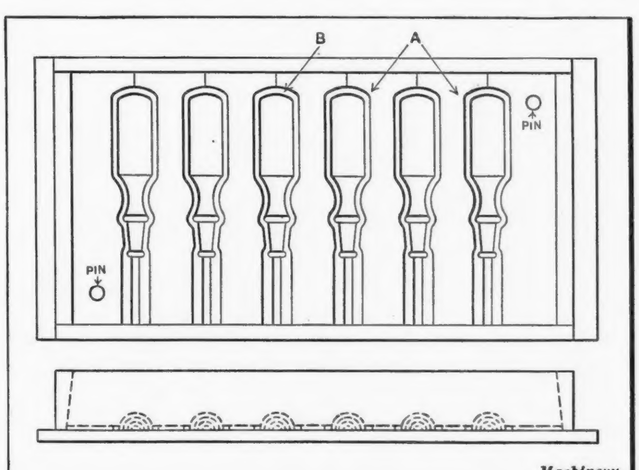


Fig. 2. Arrangement of Plaster Patterns

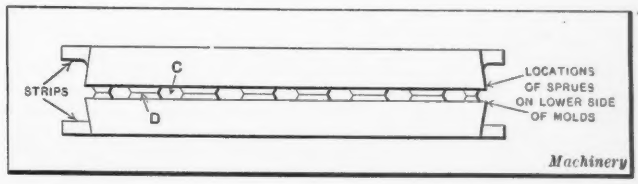


Fig. 3. Appearance of Assembled Top and Bottom of Mold, showing Finish Strips

After these plaster patterns have been made, they are arranged on a board, as shown in Fig. 2, and are built up so as to provide for finishing the face of the cast-iron mold. A thickness of heavy wrapping paper may be used for this purpose. Wood strips *A* are then arranged between the plaster patterns so as to provide spaces *B* around each pattern. These spaces form the finish strips in the cast-iron mold, and the strips *A* form the spaces *C*, Fig. 3, into which the excess material may overflow when using the cast-iron molds in the production of the various bakelite articles. The faces *D* should be ground or milled, so as to permit the mold to be securely closed on all points. In finishing the surfaces, grinding is preferable to milling because in grinding the possibility of chipping the edge of the mold is very slight. Dowel-pins should be provided in the lower part of the cast-iron mold, as shown in Fig. 4. The foundryman should be cautioned to exercise care in producing the castings so that very little scraping will be required to finish the mold. It is advisable to pour the cast-iron mold from sprues placed as shown in Fig. 3. Fig. 3 shows the mold assembled and also the strips provided as handles for the pressman, so that he can more easily separate the molds.

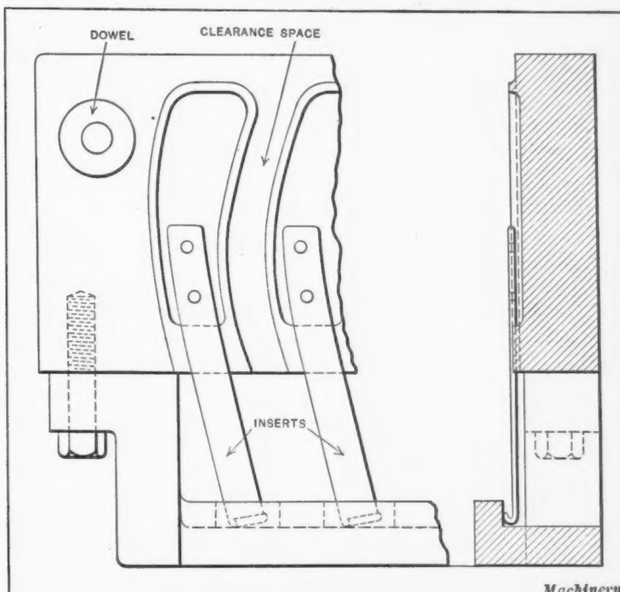


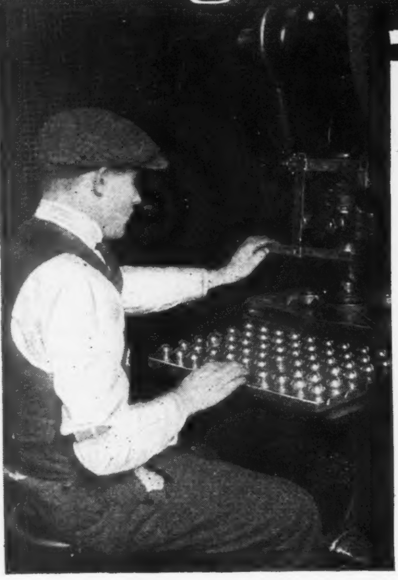
Fig. 4. Method of preventing Laid-in Blades from becoming displaced by the Plastic Material

Fig. 4 shows the method of inserting and holding a horse-hoof knife blade, which when molding the handle, is laid on the material in the drag of the mold, on which the remainder of the material is pressed. There is always a tendency for the bakelite or condensite to tip or push the insert from the mold, and for this reason stops such as shown are provided. The material, when laid in these molds, is in a plastic state and it is well to provide a liberal clearance space for the overflow. This will allow the mold to close tight, and the slight fin or seam caused by the overflowing of the material can be easily buffed off.

* * *

The U. S. Commerce Reports, in a summary of industrial and trade conditions in Bavaria, says that labor conditions are rapidly improving, the working classes showing a tendency toward greater willingness to do a fair day's work in return for their wages.

Manufacturing Ball Casters



Methods Employed in the Plant of the Schatz Mfg. Co., Poughkeepsie, New York, in the Quantity Production of "Acme" Ball-bearing Casters

By FRED R. DANIELS

THE ball-bearing caster, the manufacture of which is described in this article, is made entirely of strip stock, and no fastenings, such as rivets or pins are employed in its construction; the processes used in its manufacture, therefore, offer a great deal of interest to the mechanical mind. This caster is made by the Schatz Mfg. Co. of Poughkeepsie, N. Y., and is known by the trade name "Acme." The characteristic of this caster is universal rolling action. As may be seen by referring to the sectional view, Fig. 5, the caster consists of a large surface ball, which is retained in a cup or shell and which revolves upon a number of small anti-friction balls that travel on a steel cup-shaped disk, or raceway, within the outside shell. The action of the large ball causes the smaller bearing balls to roll between the raceway and the large ball so that all the bearing balls are kept circulating in the bearing and coming into contact with the surface ball as it revolves. In this way the load is distributed over all the bearing balls, although all are not so burdened at one time. An inspection of the construction as shown in Fig. 5 will clearly indicate the arrangement and will also make it apparent that very little friction can be produced.

Drawing the Retainer Shell

The manufacture of the caster parts represents mainly a series of punch press operations. The shell is made from cold-rolled strip stock, 0.032 inch thick, and is formed in four major press operations, the first of which is shown in Fig. 1. This is a blanking and drawing operation and is performed on a Ferracute inclined press, fitted with a combination blanking and drawing punch and die of standard construction, employing the usual rubber buffer attachment. The various stages in the development of the shell are shown in Fig. 4, the appearance of the shell after the completion of the first press operation being shown in the view at *A*.

The second operation consists of drawing the shell to the shape shown at *B*, the set-up for which is shown in Fig. 2. This is a plain drawing operation, the construction of the equipment employed embodying no special features. A tray of shells that have come from the machine employed in the first press operation may be clearly seen, as well as some of the parts after the second drawing operation. Attention is called to the flaring edge of the shell produced in this operation and to the irregularities which are quite noticeable in the edge of the shell. The following operation consists of trimming the flared edge, using an ordinary trimming die. As a result of this the correct height of the shell is established which, for this particular finished shell will be 1⅛ inches. As will be apparent later, when the assembly of the caster is described, the trimming of the shell at this stage of the manufacture produces a tapering edge which improves the appearance after the shell has been closed over the assembled ball.

The next operation consists of finish-drawing the shell, and is performed on an inclined Ferracute press, so that when the work is ejected from the die it will fall from the press into a suitable receptacle, thus eliminating unnecessary handling. The result of this operation is to straighten the flaring edge of the shell and to size and form it to the shape shown at *D*, Fig. 4. The large outside diameter of the size of the caster shell illustrated is 1⅛ inches.

Up to this stage of manufacture the work performed on all sizes and styles of shells is the same. There are various styles of casters manufactured by the Schatz Mfg. Co., the distinguishing characteristics of which are the methods employed in attaching the caster to the articles for which they are intended. Special designs are not considered here, but the two regular types, flange and stem, are illustrated and described. The operation following the finish-forming of the shell is that of punching a hole in the top. For the flange

Fig. 1. Blanking and First Forming Operation on Ball Caster, performed on Ferracute Inclined Press

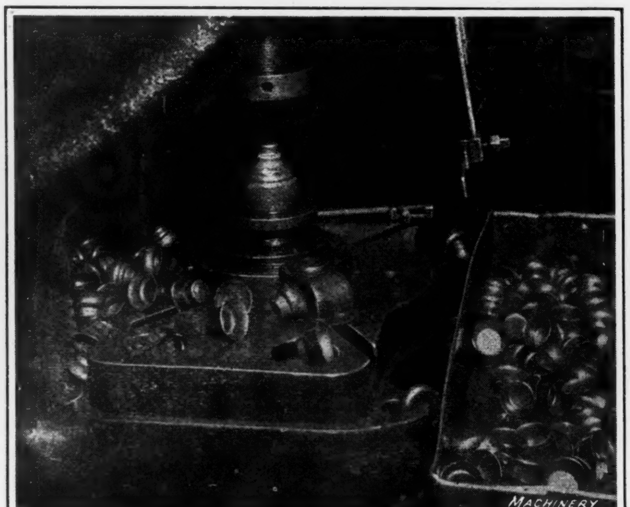


Fig. 2. Second Drawing Operation on Ball Caster Shells. Note Irregular Edges of Shells

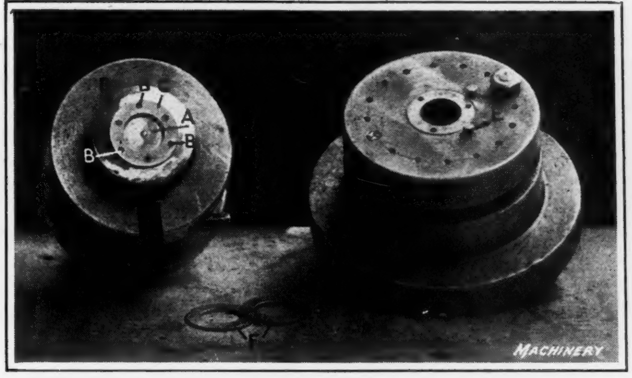


Fig. 3. Punch and Die employed in blanking and piercing the Holes in Flanges on a Double-action Press

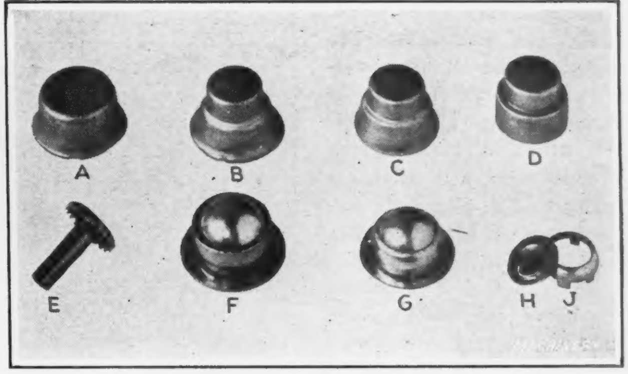


Fig. 4. Various Steps in forming the Shells; also Condition before and after Shell is closed about the Ball

type, see Fig. 5, this hole *A* is merely for the purpose of stringing the shells during the subsequent cleaning and electroplating operations; for the stem type, the hole is punched large enough to enable the stem to be assembled and riveted over on the inside. The stems are purchased from an outside concern and are swaged into the shells on a power press. After the holes have been punched, the shells are stamped with the trademark and taken to the soda kettles and cleaned, and thence to the tumbling barrels where they are tumbled in dry sawdust for one hour. The shells are next electroplated with either nickel or brass, as required. They receive a final dry tumbling to produce a polish after being plated, and the brass plated parts are lacquered to prevent oxidation. The stem or flange, as the case may be, is then assembled. The production time for each press operation on the shell is 1500 pieces per hour.

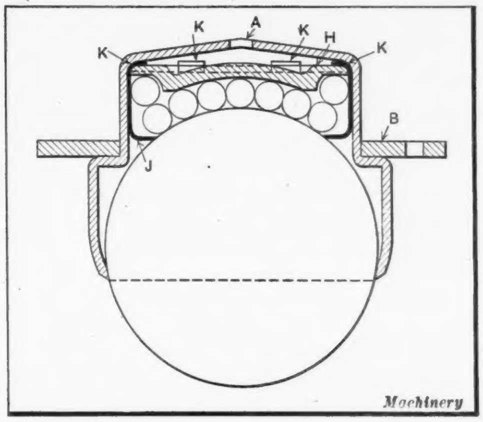


Fig. 5. Sectional View of Flange Type Ball Caster

Making and Assembling the Flange

The caster flanges may be made to any size or shape, but for the purpose of description, the work done on a circular flange is representative of all flange operations and this style only will be dealt with. A circular flange for the size of caster described in this article is made of three-quarter hard cold-rolled strip steel, 1 7/8 inches wide and 0.065 inch thick, and is shown at *F*, Fig. 3. In a single operation the flange is blanked out, punched to fit the outside of the shell, and pierced for receiving the rivets by means of which the caster is attached. The operation is performed on a double-action press, and the punch and die used in punching out the parts are also shown in Fig. 3. As the stock is fed into the press, the center punch *A* descends on the stock and holds it, while three small piercing punches within holes *B* descend through ring *C* and produce the rivet holes in the flange. Immediately following this operation, the center and blanking punch *D* is brought into operation, punching out the hole and blanking the flange. Between the three holes in ring *C* through which the piercing punches operate, three other holes are located, as shown, in each of which a light coil spring is carried for the purpose of forcing the completed flange from ring *C* after it has been made. By this arrangement ring *C* is provided with a yielding construction so that the flanges will be prevented from adhering to the ring through films of oil, burrs, or other causes. A knock-out is also provided in the die, in the form of the two plunger-pins *E*. In other respects, the construction of both the punch and the die does not contain any special features.

Fig. 6. Punch Press equipped with Indenting Tool used in assembling Caster Flanges

Fig. 7. Punch and Die employed in blanking the Hemispheres from which the Ball is made

The next step is to clean, tumble, and electroplate the flanges in the manner outlined in the description of the manufacture of the shell, after which a punch press equipped with a special indenting tool *A*, Fig. 6, is employed for assembling the flange to the shell. The illustration shows a view taken from below the platen level to enable the tool to be more clearly seen. The flanges are pressed firmly against the shoulder of the shell, as may be seen by referring to Fig. 5, and at the completion of the press stroke are pinched on by means of the special tool. This tool is similar in arrangement to a hollow mill having three inserted cutting tools with cutting edges on the end arranged so that the three indentations made in the flange will wedge the metal against the body of the shell, thus securely holding it in place.

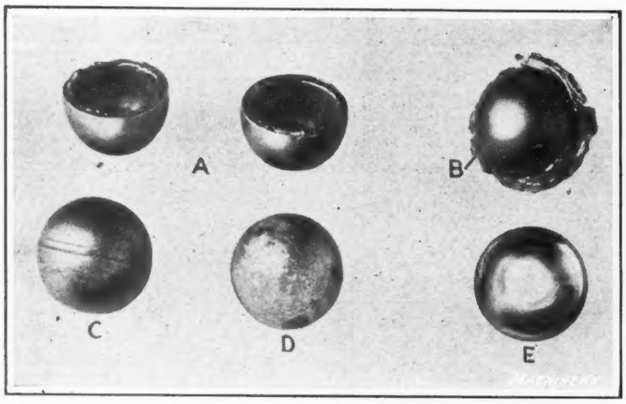


Fig. 8. Various Stages in the Manufacture of the Caster Hollow Ball

On the stem type caster a two-piece socket, shown at *E*, Fig. 4, is employed for the purpose of attaching it to the leg of the furniture. This socket, or grip neck, consists of a serrated tooth grip washer which is first blanked from 1⅜- by 0.035-inch hot-rolled stock and then cupped to the shape shown. The sleeve member of the socket is blanked from cold-rolled stock, 1 7/16 inches wide, 0.022 inch thick, and formed in two subsequent operations. The details of the punch press operations required to make this holding member are not shown, since no equipment or methods of special interest are involved. When this socket is driven into a hole in the leg of the furniture, it is held securely by the gripping member. The hole should be drilled somewhat deeper than the length of the sleeve part, so as to enable the knob on the end of the stem to be driven through the sleeve. The sleeve is designed to expand at its upper end, when the knob is driven through, so that when it is fully assembled the sleeve will contract to its normal diameter and hold the caster in place by closing around the neck under the knob of the stem. The flange and the sleeve are finally riveted together, after which they are tumbled.

Construction of Caster Bearing

The ball bearing on which the main caster ball bears consists of a saucer *J* and a disk or ball race *H*, Fig. 4. These two members form a housing for the small alloy steel bearing balls, the location and arrangement of which may be seen by inspecting the sectional view of the caster, Fig. 5, in which the parts are designated by the same reference letters. The saucer is blanked, pierced and drawn in one operation, a combination punch and die being employed. The material from which the saucer is made is cold-rolled strip stock, 1 9/16 inches wide by 0.015 inch thick. The ball race is blanked and drawn in two press operations, the second of which is a finish-forming operation. The material from which the race is made is cold-rolled chrome steel, 1⅞ inches wide by 0.055 inch thick, and is carburized in an oil-burning furnace at 1750 degrees F. for three hours and then pot-cooled. A charcoal-base carburizer is used, the parts being packed and sealed in nichrome carburizing pots. After carburizing, the races are reheated to 1550 degrees F., preparatory to hardening and are afterward tempered in oil at 375 degrees F. Finally the race and the saucer are pickled and rustproofed by the galvanizing process.

Making the Hollow Surface Ball

The manufacture of the hollow surface ball, which takes the place of the roll in an ordinary caster, is a rather unique process, various stages in its evolution being shown in Fig. 8. Briefly, these balls are made from two hollow hemispheres welded together. The hemispheres *A*, Fig. 8, are blanked and formed in one operation, a double-action press equipped with the combination blanking and drawing die shown in Fig. 7 being employed. The diameter of the punch is 15/16

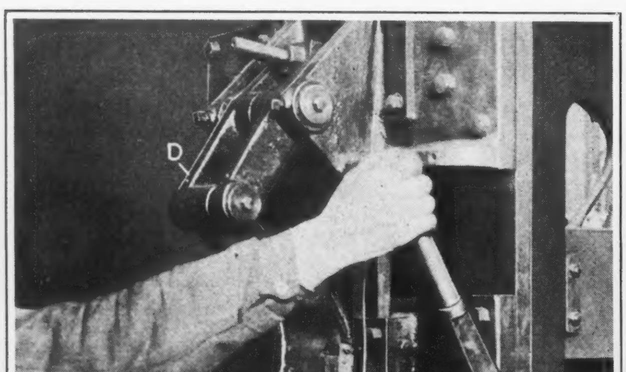


Fig. 9. Operation of Butt-welding the Two Hemispheres from which the Hollow Caster Ball is made

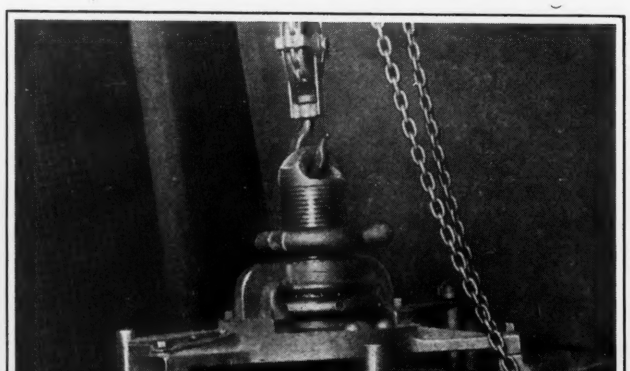


Fig. 10. Specially Designed Ball Grinding Machine, showing a Row of Balls after being rough-ground

inch, which for drawing a hemisphere requires that the blank diameter should be 1 5/16 inches. The punch enters far into the central hole in the die, so that the hemisphere is pushed through the die. The stock is 1¾ inches wide by 0.109 inch thick, hot-rolled, and the two hemispheres are electrically welded together on a National Electric Welder Co.'s alternating-current 60-kilowatt butt welder which delivers current to the work at a voltage of about 5 volts from a 220-volt, 60-cycle power supply.

Fig. 11. A Battery of Vertical Rotary Lapping Machines especially designed for Use in the Manufacture of Hollow Caster Balls

This operation and the specially equipped welding machine is shown in Fig. 9. The machine is equipped with two copper cup dies *A* and *B*, of special design, which are connected directly with the source of power supply as clearly shown in the illustration. The length of traverse of the upper die-head *C* is controlled by means of the operating lever and produces the desired amount of pressure, when making the weld, through the medium of the toggle-jointed link *D*. In the illustration a ball is shown after being welded, seated in the lower die, from which the flash produced at the weld may be seen. A better idea of the appearance of the two welded hemispheres may be had by referring to Fig. 8 at *B*. The members before being welded are not true hemispheres, and consequently after the ball has been welded, it is slightly elliptical in shape. In performing the weld, the operator simply places one hemisphere in the lower die, lays its mate on it, switches on the current, and operates the hand-lever until the upper die closes over and aligns the two parts, thus completing the weld. The production time is 400 welded balls per hour.

After welding, the next operation consists of trimming the flash from the ball, and the tooling equipment used is shown in Fig. 12. The operation is performed on a Ferracute press, on the table of which, in back of the trimming die, may be seen a pile of trimmings, from which a good idea of the size and nature of the fin can be had. The condition of the ball after this trimming operation is shown at *C*, Fig. 8. The trimming operation is followed by swaging the slightly elliptical balls in a power press, using the equipment shown in Fig. 13, preparatory to the finishing machine operations. The finishing operations consist of grinding and lapping; for the performance of these operations use is made of specially designed machines.

One of the special grinding machines employed in the manufacture of the balls is shown in Fig. 10 and consists simply of an annular channel or raceway in which the balls are placed and against which a horizontally mounted abrasive wheel revolves. The wheel is mounted eccentrically in relation to the annular raceway, both members revolving in the same direction, but with the grinding wheel traveling at a greater velocity. With this arrangement the balls are ground to the desired degree of roundness. It will be fully appreciated that the service required of caster balls does not demand the same degree of perfection as regards roundness that the commercial solid steel ball does, such as is used in high-grade bearings and for gage inspection purposes. Therefore, the close limits usually maintained in steel ball manufacture are not essential. This statement should not be construed to mean that the process employed by the Schatz Mfg. Co. does not, to all intents and purposes, produce round balls, for on the contrary, a very satisfactory product is obtained. However, the painstaking inspection for roundness which is necessary in the manufacture of high-grade solid steel balls is not, in this case, required.

The balls are first wet rough-ground, their appearance after this operation being shown at *D*, Fig. 8. They are next heat-treated in the same manner as are the ball races, except that in carburizing, the parts are left in the furnace eight hours instead of three on account of the greater thickness of the stock from which the balls are made. After heat-treating, the hardened balls are returned to the ball grinding machine and are finish-ground to within lapping limits, after which they are ready to be lapped to size.

The lapping operation is performed on specially designed machines, a battery of which may be seen in Fig. 11. The

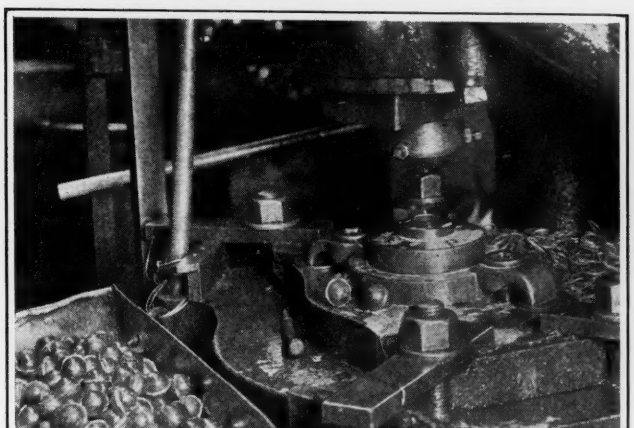


Fig. 12. Set-up employed in removing the Flash produced in welding the Balls. Note Pile of Trimmings back of Die

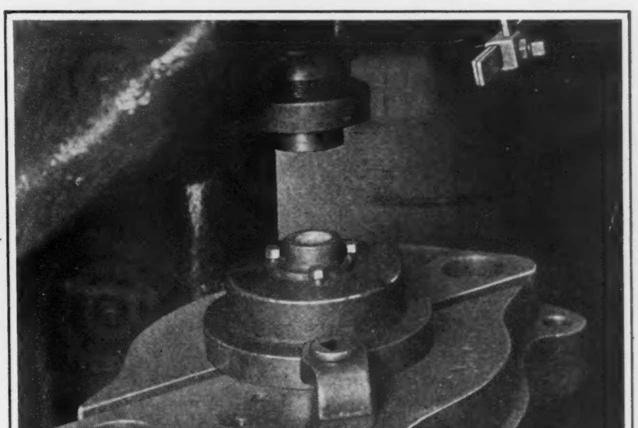


Fig. 13. The Ellipticity of the Balls is reduced to Approximate Roundness in Swaging Dies on a Ferracute Press

balls are placed in an annular channel, and liberally treated to a mixture of oil and fine emery. A revolving cast-iron lap or disk *A*, held in the vertical spindle of the machine, is then lowered into contact with the balls, and abrasions caused by the grinding wheel and all other surface defects are gradually lapped away. It will be noticed that the lapping machines are equipped with a dial gage for determining the proper finished diameter of the balls. This completes the machining operations employed in manufacturing the ball, and the next operations are those confined to the electroplating department, where the balls are cleaned in soda, tumbled in sawdust, and nickel-plated by the electro process. The appearance of the finished ball is shown at *E*, Fig. 8.

Assembling and Inspecting the Casters

The assembled caster, shown in section in Fig. 5, gives a very good idea of the caster construction. This is the flange type. For casters having a stem, this part is riveted into hole *A*, as previously stated, and no flange *B* is required. When the shells are delivered to the assembling room with their flanges or stems assembled, as the case may be, they are set into boards which are drilled for receiving five dozen shells. One of these boards is shown in the heading illustration. In assembling, the chrome-steel bearing raceway *H* is first dropped into the saucer *J*, Figs. 4 and 5, and the projecting lugs *K* on the saucer are bent over so as to keep the race intact. These two parts, thus assembled, are then put into the shell and a quantity of 1/8-inch alloy steel balls dropped into the housing, in which they become seated in the raceway within the saucer.

For loading the balls into the caster ball bearing, a special machine is employed as shown in Fig. 14. This machine delivers thirty-five 1/8-inch balls from the hopper *A* through the brass feeding tube *B* into the caster shell which is held under the thimble *C* in the manner shown in Fig. 15. By pressing up on this thimble the lever *D*, Fig. 14, which fulcrums at *E* is forced outward, withdrawing pin *F* from a slot in the feeding tube. While this pin is being withdrawn, the pin *G* at the upper end of the lever enters a slot in the tube and prevents more than a predetermined number of balls from being released when the shell is being loaded. The balls are kept circulating in the hopper, so that the tube is always loaded with balls. The slot in which the upper pin enters the feeding tube can be clearly seen in the illustration Fig. 14, as well as the balls which have just been released and which are being supported by the lower pin. By this simple arrangement means are provided by which 1200 shells may be loaded per hour, and each loading is mechanically sure of containing the correct number of balls. Another view of one of the loading machines, in which the actual operation of loading a shell may be seen, is shown in Fig. 15.

The large balls are now dropped in the shells which have previously been placed in the assembling board, and are taken to a machine such as shown in the heading illustration. This is a Ferracute press, equipped with a simple closing punch and die by means of which the shell is closed around the ball. It will be remembered that in describing the trimming operation on the shell special mention was made of the fact that the edge was given a bevel in trimming and that this bevel was made for the purpose of improving the appearance of the assembled caster. By inspecting views *F* and *G* in Fig. 4 a good idea of the appearance of the caster before and after the final closing operation may be had, in which it will be seen that this bevel, when the shell is closed, is formed nicely over the curvature of the ball (see also Fig. 5) and leaves no abrupt sharp surface change.

The casters receive a final visual inspection in which all those having surface defects are rejected. A running test is also given the caster, and if the ball binds in the shell or does not function properly the caster is rejected. The casters are finally carefully packed in sets of four casters to a box.

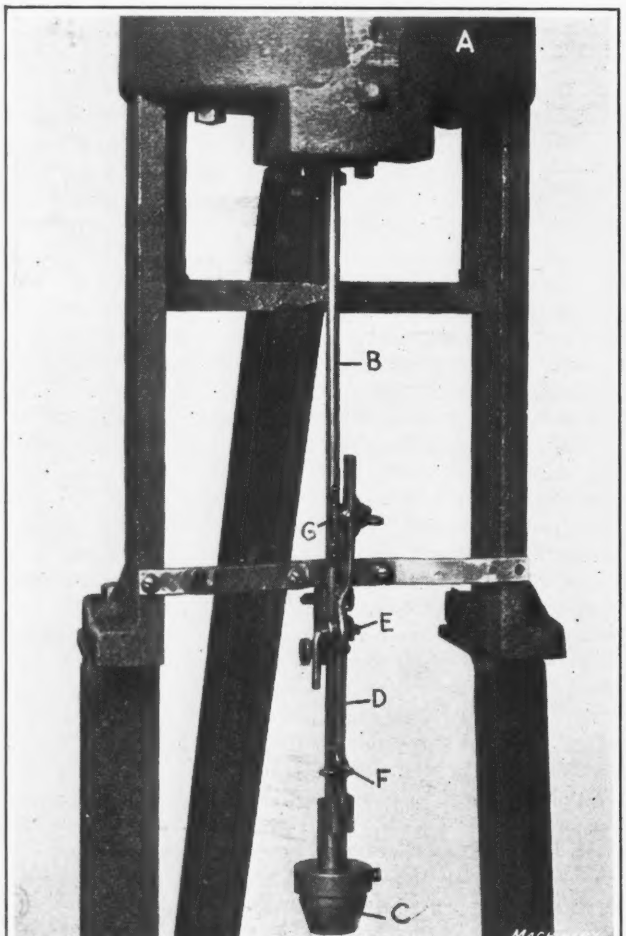


Fig. 14. Loading Machine for depositing Caster Bearing Balls in the Shell

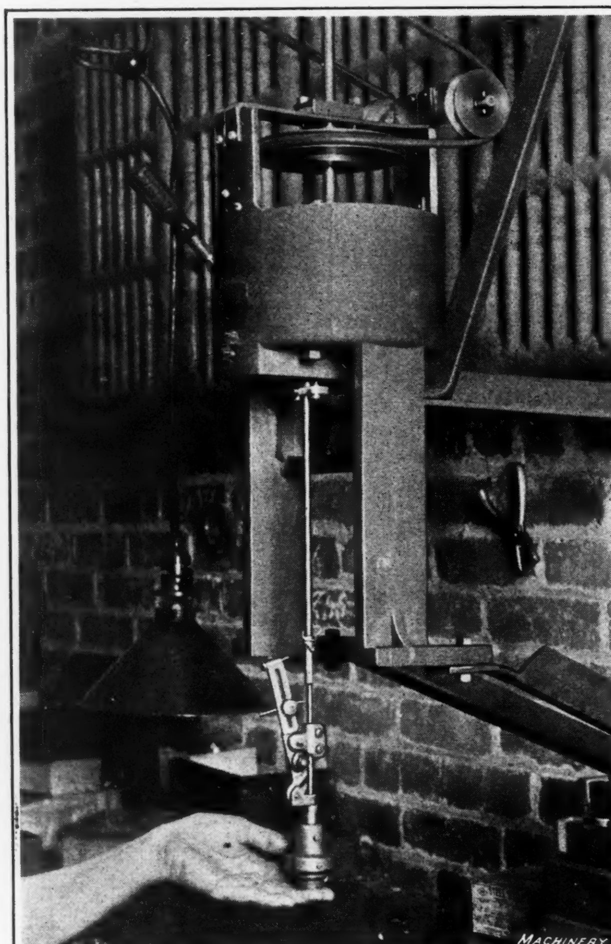


Fig. 15. Operator holding a Shell in the Thimble, preparatory to releasing the Ball

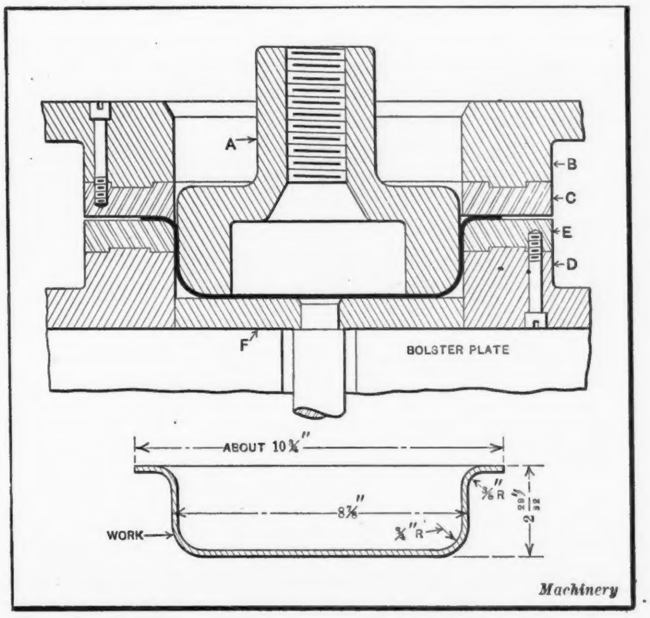


Fig. 1. Double-action Die employed in First Drawing Operation on Blank

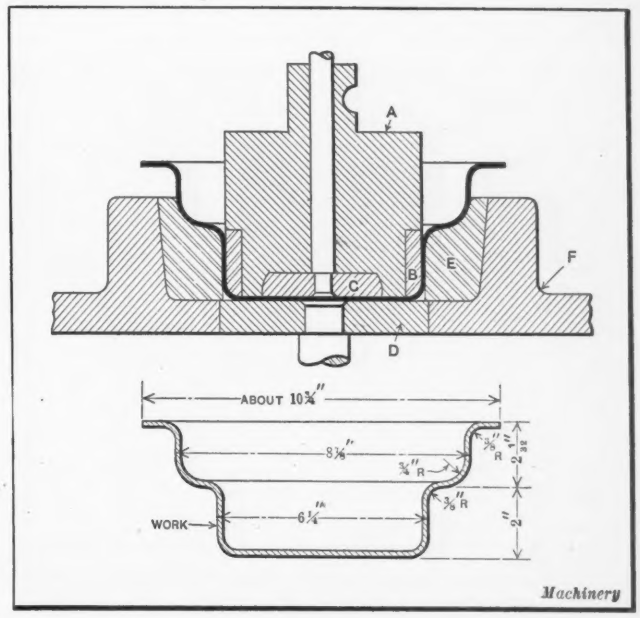


Fig. 2. Die that is employed in lengthening the Shell and reducing the Diameter

Dies for Automobile Rear Axle Housings

By J. BINGHAM, President, The B. J. Stamping Co., Toledo, Ohio

THE drawing and forming dies employed in the manufacture of rear axle housings for a certain type of automobile are here illustrated and described. These dies have worked very satisfactorily, having produced thousands of these housings. By the methods followed in the production of this part, various taper shells can be readily produced which, as a rule, are difficult to manufacture. Each illustration shows one of the dies and a dimensioned drawing of the housing or shell as it appears after having been operated upon by that particular die. The description of the dies is given in the order in which they are used. The first operation consists of cutting a blank 14 inches in diameter from sheet steel, 5/32 inch thick. This operation is performed on a plain blanking die, which is of standard construction and is therefore not illustrated in this article.

The first shaping operation is performed by the double-action drawing die illustrated in Fig. 1, which is used on a double-action press. In the operation of this die, blank-holder *B*, which has a hardened and ground steel ring *C* on its lower face, descends and exerts pressure on the blank that has previously been placed on the hardened and ground steel die ring *E*, which is mounted on the die-block *D*. Then punch *A* descends and forces the blank into the cavity of the die, thus drawing it to the desired shape. Punch *A* is an iron casting, cored out at the center in order to make it lighter. By this means a closer-grained metal than would be possible if the punch were cast solid is obtained, so that this type of punch has proved more satisfactory in several ways than a solid one. Rings *C* and *E* are ground on both sides to eliminate all tendency of spring in the blank-holder

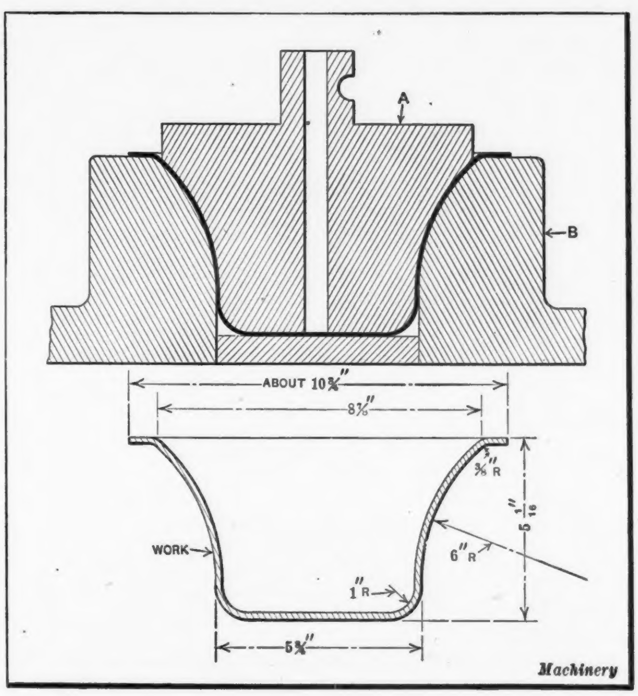


Fig. 3. Forming Die which reshapes the Shell Body without changing the Length

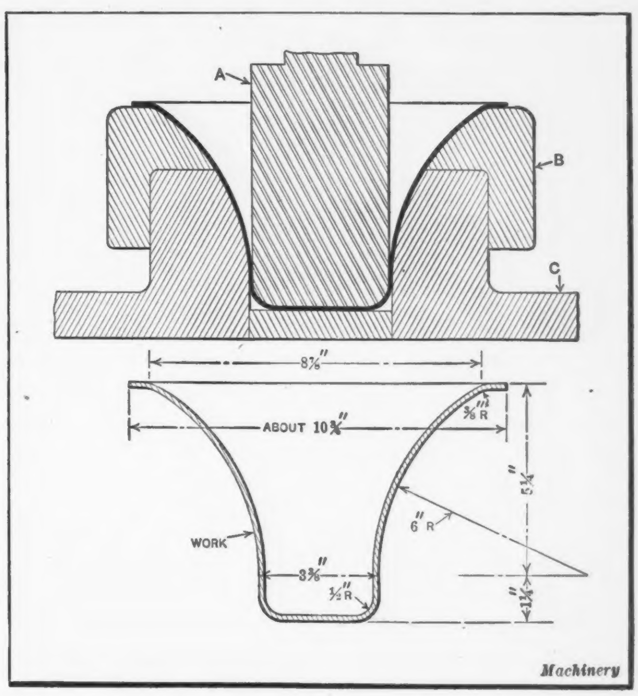


Fig. 4. Drawing Die used to still further reduce the Shell Diameter and increase the Length

or die-block. In dies of this kind the faces of these rings should be ground flat unless the metal is of such thickness that the exposed surface of the rings must taper toward the center of the die in order to permit the metal of the blank to thicken as the diameter is reduced. The machine screws which secure these rings to their respective holders are staggered in circles concentric with the hole in each ring; this tends to eliminate spring in the blank-holder and die-block. The die is equipped with a knock-out pad *F* for removing the shell from the die after the punch has ascended, while the blank-holder serves as a stripper for forcing the shell from the punch on the return stroke of the press ram.

Dies Employed in Reducing the Shell Diameter and Increasing its Length

The die illustrated in Fig. 2 is employed to lengthen the shell and reduce the diameter of the closed end. The shell as produced in the preceding operation is placed in the recess of die ring *E*, the contour of which is similar to that of the bottom of the shell, so that the shell is correctly located for this operation. As punch *A* descends, the closed end is drawn to the dimensions given, while the portion of the shell remaining in the recess of the die ring at the completion of the operation, assumes approximately the same shape as the recess. Punch *A* is also made of cast iron, but a hardened and ground steel ring *B* is provided for contact with the shell. This ring is pressed on the punch. The punch is also furnished with a knock-out pad *C*, which forces the shell from the punch on the return stroke of the press ram, while knock-out pad *D* removes the shell from the die. Die ring *E* is hardened and ground, and its circumferential surface has a taper of 1.5 degrees. It is secured in die-holder *F* by means of bolts.

The forming die illustrated in Fig. 3 reduces the diameter of the body of the shell although the diameter of the flange remains the same as produced in the first drawing operation. In this operation, punch *A* forces the shell into die *B* until the flange of the shell comes in contact with the upper surface of the die. The punch and die are both made of cast iron and are equipped with devices for removing the shell from each respective part after the performance of the operation.

Fig. 4 illustrates a die that is used to still further reduce the shell body diameter, at the same time increasing the length. At the beginning of the operation, die ring *B* is in a raised position relative to die-block *C*, which permits it to locate the shell properly for the operation. The raising of the die ring is accomplished by means of springs and bolts, which are not shown in the illustration. During this operation the shell and die ring are pulled down by punch *A* as it descends, until the inner surface of the die ring comes in contact with the upper surface of the die-block as shown in the illustration, at which time the shell has been drawn to the desired shape. The die is provided with a knock-out pad for forcing the shell from the die after the performance of the operation. There is no tendency for the shell to adhere to the punch in this operation, and for this reason no knock-out device has been provided for the punch.

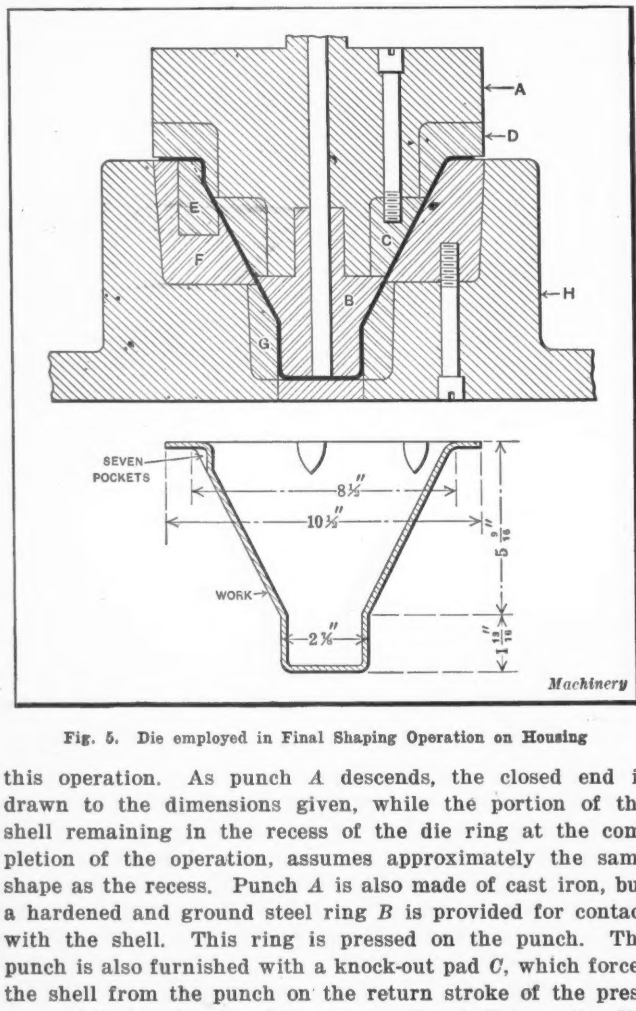


Fig. 5. Die employed in Final Shaping Operation on Housing

Die Used in Final Shaping Operation on Shell

The final drawing operation on the shell is performed by the die illustrated in Fig. 5. In this operation the main body of the shell is drawn to a taper, the surface of the body adjacent to the closed end is straightened, and seven pockets are formed close to the flange. Punch *A* is also made of cast iron, but pieces *B*, *C*, and *D* which come in contact with the shell are hardened and ground steel pieces, secured to the punch. By constructing the punch in this manner, the hardening and grinding of the various parts were greatly facilitated. It will be noticed that the die is constructed in a similar manner, the die-block *H* being an iron casting, and parts *F* and *G*, which are inserted in it, being hardened and ground steel pieces. The pockets are formed in the shell by means of seven hardened and ground steel pieces *E*, inserted in die ring *F*. By having these pieces made separate from ring *F*, the manufacture of the die was a more simple proposition, and as these pieces wear more rapidly than the remaining die parts, they can be readily replaced when necessary. Both the punch and die are provided with knockout devices for removing the shell from the respective parts after the operation has been performed. The illustration shows the flange diameter reduced to 10½ inches, but this is performed in a later operation on a trimming die which is not illustrated.

Two more operations are performed on the shell before the part is finally completed. The first of these consists of punching holes around the flange, which is done by a piercing die of standard construction. The final operation consists of cutting a hole in the closed end of the shell to permit the housing to be fitted over the axle tube of the automobile. Neither of these dies is illustrated.

* * *

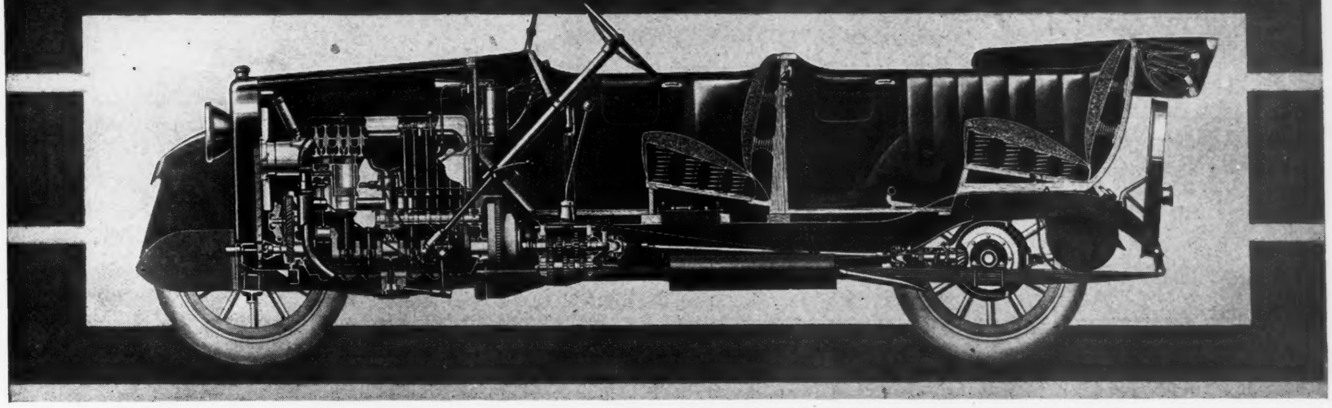
HARDNESS TESTING BY MAGNETIC QUALITIES

A British firm has developed an apparatus for testing the physical qualities of steel after heat-treatment by means of the magnetic method. The principle on which this instrument is based is that magnetic retentivity of a steel is a function of its hardness. The method of using this apparatus is as follows: First a specimen (usually a turned piece 3 inches long by 1½ inches in diameter) is subjected to the heat-treatment required to be investigated. It is then tested for magnetic hardness by being laid inside a standard magnetizing coil, while a direct current from the mains is flashed on the coil, which magnetizes the steel to saturation. The specimen is then removed from the magnetizing coil and is placed in a small search coil, which is directly connected to a Grassot fluxmeter, after which it is removed from the ballistic coil and a reading is obtained on the fluxmeter, which represents the hardness of the specimen.

* * *

An interesting diagram has been prepared by *Safety News*, showing the position of ladders of various lengths to insure safe use. The angle of 75 degrees has been found, through a series of experiments, to give the greatest degree of safety, and to secure this angle, all that is necessary is to place the foot of the ladder a distance approximating one quarter of the length of the ladder away from the vertical. This angle will prevent undue straining of the ladder, or slipping.

Machining Operations on the Nash Motor



Use of Special Machines, and Interesting Methods of Equipping Standard Machine Tools

By EDWARD K. HAMMOND

IN every industrial plant in which there are large numbers of parts to be machined, local conditions or peculiar requirements of the work may call for the use of special methods of handling the product and for performing machining operations. Such methods may be of a character which makes them special in the sense that while being well suited to the requirements of the job on which they are employed, they are not likely to be applicable in many other cases; or it may happen that methods which have provided a satisfactory solution of local problems in one shop could be applied with satisfactory results on many other classes of work. The description of purely special methods of machining parts or handling raw material and finished pieces may be of considerable interest to mechanical men, but their practical value is negligible, and for that reason the selection of subject matter to form the basis of articles published in MACHINERY is usually made with a view to describing interesting production methods that can be applied, with suitable modifications, in handling the work in various shops.

Where large numbers of parts have to be carried about a manufacturing plant on trucks, the maintenance of open aisle space will usually be found to overcome delays caused by the blocking of trucks while in transit from one department to another; but where trucks have to be taken from floor to floor on an elevator, trouble is likely to be experienced in the gathering of trucks at the elevator shaft more rapidly than they can be handled. Engines of motor cars built by The Nash Motors Co., in Kenosha, Wis., have the cylinder block and crankcase cast integral, and in laying out the departments in which machining operations are done on these parts, it was desired to utilize a portion of the second floor for this part of the work. To overcome difficulties which would have been likely to arise in trucking these bulky castings from floor to floor, a conveyor system is util-

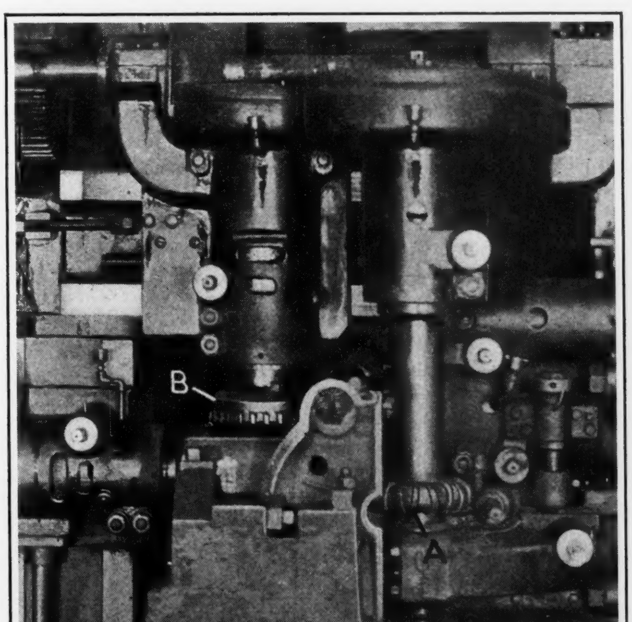


Fig. 1. Multiple-spindle Milling Machine provided with Cutter A for milling Crankshaft Bearings in Crankcases, and Cutter B that recedes to clear the Timing Gear Case; the Usual Arrangement of Facing Heads is also provided

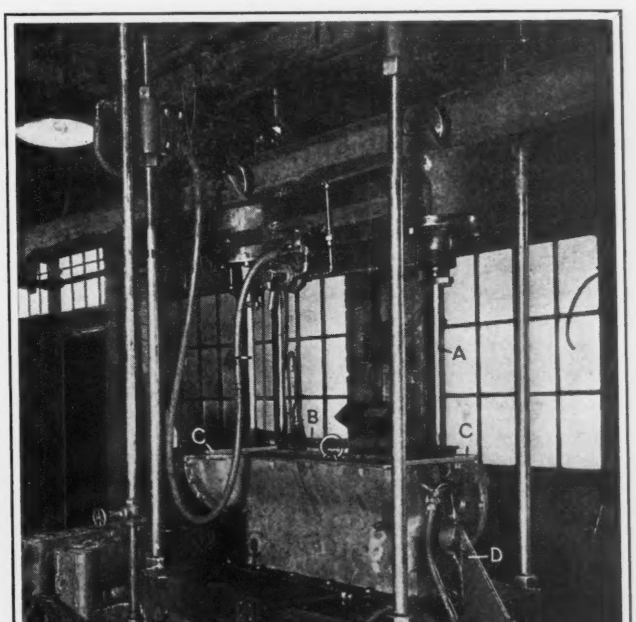


Fig. 2. Table on which Cylinder Blocks are given a Water Test. Air-actuated Plungers A hold the Work down and an Air-actuated Lever holds a Gasket over the Water Pump Connection while testing the Water Jacket

ized which carries the pieces vertically upward to the second floor, and then deposits them on a horizontal conveyor system running from machine to machine. After the operations done on this floor are all completed, the castings run on an inclined gravity carrier down which they roll to the line of machines in the main crankcase department on the ground floor.

Milling Crankcase Castings

As the castings run off the gravity carrier, they are first set up on a nine-spindle planer type milling machine, Fig. 1, built by the Ingersoll Milling Machine Co., Rockford, Ill., which has been designed to do its work in a somewhat different manner from that ordinarily employed for machining cylinder blocks or crankcases of motor cars. There is nothing of special interest in regard to the work-holding fixtures or provision made for milling flat surfaces, but it is not common practice to use form cutters on a machine of this type for milling out the crankshaft bearings at the same time that the facing operations are performed. One of the cutters for performing such an operation on the Nash crankcase will be seen at *A* in Fig. 1.

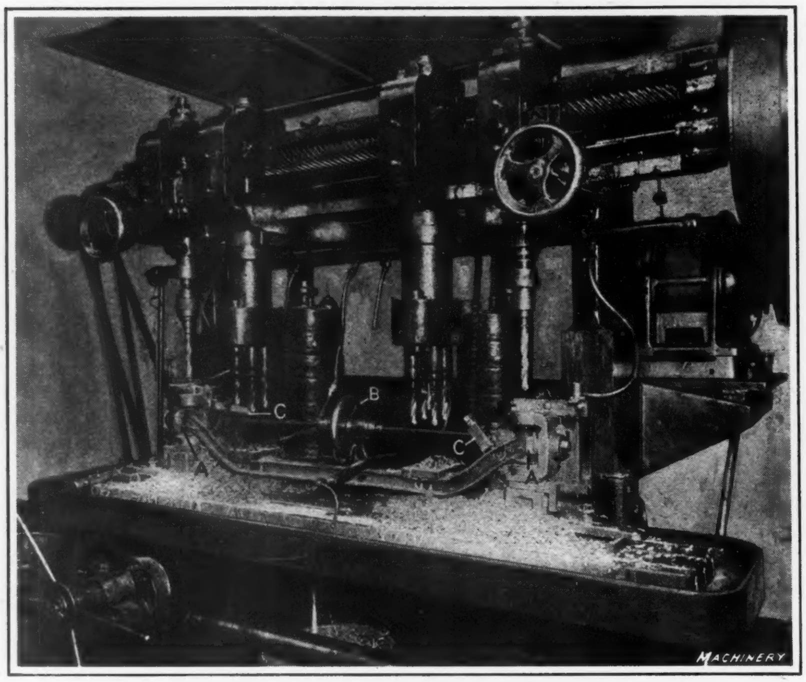


Fig. 3. Multiple Drilling Machine equipped with Two Single Drills and Two Cluster Heads for simultaneously drilling Twelve Holes in Front Axles

Attention is called to the fact that on this Ingersoll milling machine there is a set of cutter-heads provided at both the front and rear of the housings, so that as the string of castings is carried through on the table, one set of cutters takes a roughing cut while the others are set to provide for finish-milling the same surfaces. Another interesting feature of this machine is the provision made for rough-milling the motor cover flange. To provide for the simultaneous performance of this operation on the same machine that performs other operations on the cylinder block and crankcase castings, it was necessary to provide the cutter-head with an automatic feed movement on the rail, so that the cutter carried by this head is able to recede sufficiently to clear the timing gear case on each casting. After completing this movement, the head again moves forward to perform its operation on the next motor cover flange. The milling cutter used for handling this part of the work is shown at *B*. Of course the possibility of building a machine for operation along these lines presented itself through having the crankcase and cylinder block cast integral. On this job the rate of production is sixty castings in a ten-hour day.

Water Test for Cylinder Blocks

For testing the water jacket on cylinder blocks to see that it is leakproof, use is made of the special apparatus shown in Fig. 2. It consists of a table with a rubber gasket on which the cylinder block is placed, as shown in this illustration, and held down by air pressure. Quite an interesting application of an air-operated trolley hoist has been made for serving the double purpose of carrying these castings and providing for clamping them down while the water test is being conducted. By referring to the illustration it will be seen that running on the usual form of I-beam track there is a trolley provided with two air hoists, each of which is furnished with a rod *A* that extends right down to the casting, connection between the air hoist and work being made by a chain passing over cross-rod *B*. The two air hoists provide for lifting the casting off the previous machine on which an operation has been performed, so that the trolleys may run along their rail and deposit the casting on this table where the water test is conducted.

Two flat bars *C* are next placed on top of the casting under the ends of rods *A*, after which the air valve is manipulated so that air enters the cylinders to force rods *A* against the work and hold it down tightly on the rubber gasket. It is then necessary to block the water pump connection with a gasket carried at the end of lever *D*. It will be seen that this lever constitutes an extension of a segment gear meshing with rack *E*, and a longitudinal movement may be imparted to the rack by means of an air cylinder located beneath the testing table. The segment gear and lever *D* are carried on a pivotal support, so that when rack *E* moves toward the right, lever *D* forces the gasket against the water pump

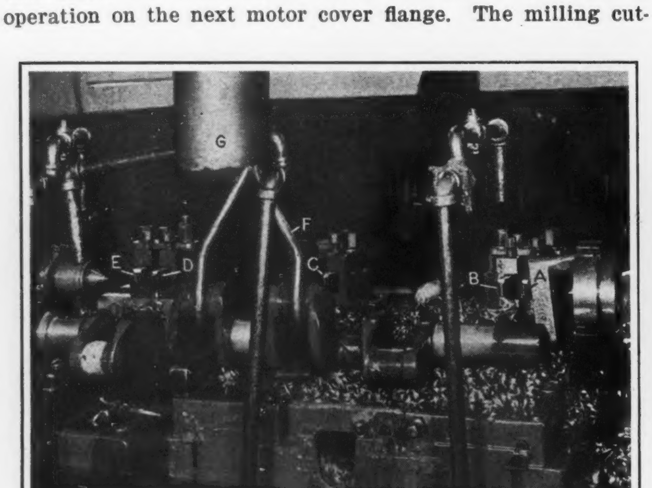


Fig. 4. Engine Lathe equipped with Double Carriages and Five Cutting Tools for simultaneously rough-turning All Line Bearings on Crankshafts

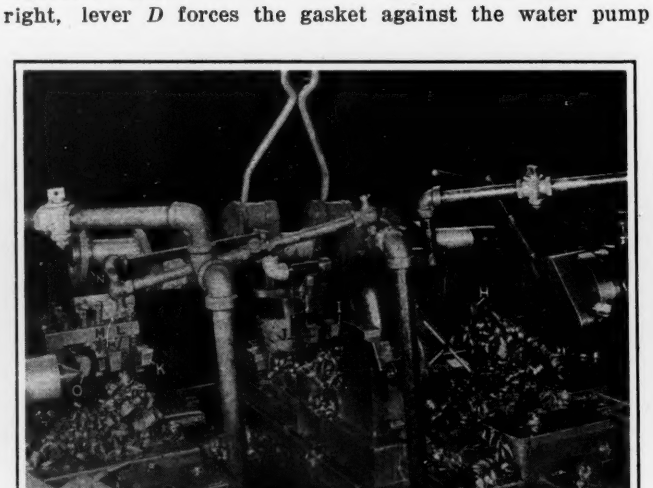


Fig. 5. Double-carriage Lathe equipped with Seven Tools for simultaneously filleting Line Bearings, straddle-facing Flange, and turning Oil Sling

connection, which securely closes it. After this, the water jacket is filled in order to test it for the presence of any leaks which may be due to defects in the casting. With this equipment it is possible for one operator to test 120 water jackets per day.

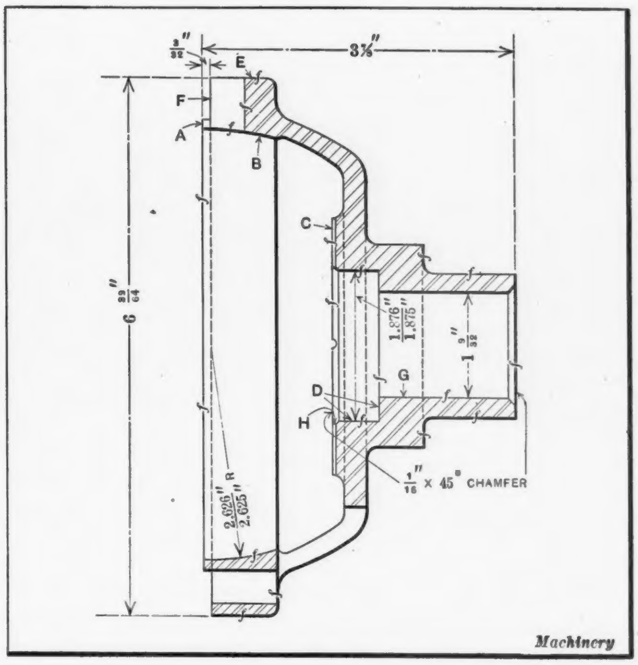


Fig. 6. Cross-sectional View of Male Half of Differential Gear Case, showing Surfaces that are machined on Flat Turret Lathe

Drilling Holes in Front Axles

On the Nash front axle, it is necessary to drill a hole at each end for the steering knuckle pin, which is later reamed to a diameter of 0.860 inch; and also to drill in each of the spring pad seats four 11/16-inch holes, and one 9/16-inch hole. For the performance of this work, use is made of a special multiple-spindle drilling machine shown in Fig. 3, which provides for simultaneously drilling all twelve holes. This machine was built by the Moline Tool Co., Moline, Ill. The work-holding fixture consists of two V-blocks *A*, which are moved inward to engage opposite ends of the work by a right- and left-hand screw turned by a handwheel *B*. After location and a preliminary clamping of the work has been accomplished in this manner, straps *C* are clamped down on the forging to assure having it rigidly held while the drilling operation is performed.

It will be apparent to all mechanics who are familiar with the Moline drilling machines, that they are not adapted for drilling clusters of holes such as those which have to be drilled in each of the spring pad seats. To adapt the Moline drilling machine for the performance of these operations, two of the spindles are equipped with multiple auxiliary drill heads of the type made by the Hoefer Mfg. Co., of Freeport, Ill. Set up in this way, a combination straight-line and cluster type multiple-spindle drilling machine is provided that enables the Nash front axles to be drilled at the rate of ninety per day. It will be apparent from the illustration that on this machine, the table feeds the work up to the drills instead of having the spindle heads move down to the work.

Rough-turning Operations on Crankshafts

As the Nash crankshaft forgings are received in the machine shop, the first step is to perform a rough-turning operation on the line bearings. This work is done on two heavy-duty lathes built by the Greaves-Klusman Tool Co. of Cincinnati, Ohio, on which the forgings are set up successively. These two operations are noteworthy on account of the large number of turning tools that are operating simultaneously, and in order to more clearly illustrate the arrangement of the tools, it was necessary to take photographs with the forgings removed from the lathe centers. However, it will be apparent from Figs. 4 and 5 that each forging is shown lying in a position quite close to that which it actually occupies when held on the centers, and in this way the reader will gather an accurate idea of the actual relationship of the respective tools to the surfaces which they machine on the work.

Referring first to Fig. 4, it will be seen that two tools *A* and *B* turn the right-hand line bearing; a tool *C* turns the center bearing; and two tools *D* and *E* turn the left-hand line bearing, the outside diameter of the flange to which the flywheel is bolted, and the oil sling. This oil sling is an annular projection located at the left-hand side of the left-hand line bearing; it is shown in its finished form in Fig. 5. The use of such a large number of tools is made possible by the special construction of the machine which is furnished with one carriage of rather unusual length, on which two toolposts can readily be mounted through the provision of a double cross-slide. Then the tools *D* and *E* are carried by a toolpost on the cross-slide of a second carriage. Evidently the possibility of using such a large number of tools enables the work to be performed at a very satisfactory rate of output, the actual production on this job being ninety crankshafts per day. Owing to the heavy weight of these forgings, it was considered advisable to furnish a hoist *F* and counterweight *G*, which enables a forging to be easily lifted into place on the machine or removed after the turning operation has been completed.

An even better idea of the possibilities of one of these double-carriage lathes for obtaining a high rate of production is shown in Fig. 5, which shows the machine equipped for performing a second operation on the crankshafts. Here it will be seen that there is a tool *H* which is employed for filleting the left-hand end of the right-hand line bearing,

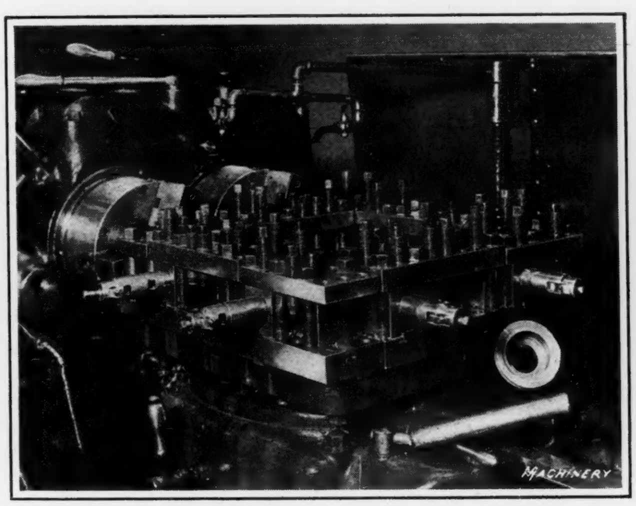


Fig. 7. Tooling of First and Second Turret Faces of Flat Turret Lathe used for machining Differential Gear Cases

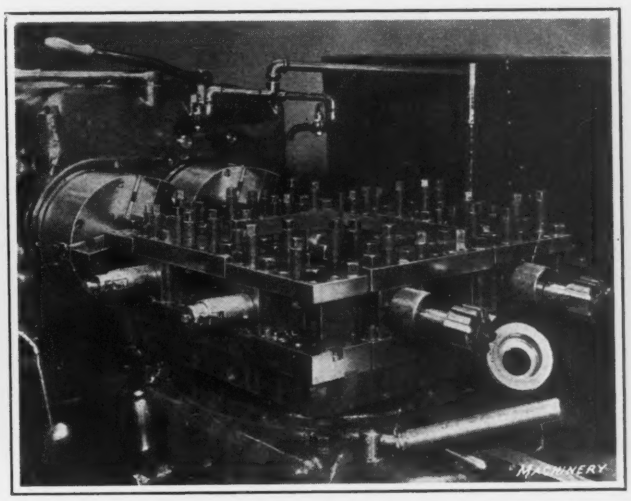


Fig. 8. Tooling of Third and Fourth Turret Faces of Flat Turret Lathe used for machining Differential Gear Cases

and two tools I and J that perform the same operation on the center bearing. At the left-hand end of the machine there is a group of four tools used for the following purposes: Tool K fillets the right-hand end of the left-hand line bearing, tools L and M form the oil sling shown at N, and tools M and O straddle-face the sides of the flywheel flange. On this job the rate of production obtained is eighty forgings per day.

Machining Differential Gear Case Castings on a Double-head Flat Turret Lathe

For machining the male half of the Nash differential gear case, use is made of a double-head flat turret lathe built by the Jones & Lamson Machine Co., of Springfield, Vt., which has cutting tools made by brazing stellite bits on machine steel shanks. This method of toolmaking enables a very efficient type of cutting tool to be produced at a relatively low cost. A feature of the tooling of the machine used for handling this work is the provision that has been made for performing operations at a single setting of the work on rather an unusually large number of surfaces. The following description will consider the four faces of the turret and explain in detail the exact nature of the machining operations that are performed by the various tools mounted at each station.

Attention is first directed to the fact that Fig. 7 shows the tools on the first and second faces of the turret, while Fig. 8 shows the third and fourth faces, and a cross-sectional view of the differential gear case casting to be machined is illustrated in Fig. 6. It will be apparent that each spindle of the double-head lathe carries one of the differential case castings, and that the turret tools are arranged in duplicate to simultaneously perform the same operation on each of these two pieces. On the first station of the turret each tool carries five cutter-bits that provide for facing surface A, Fig. 6, turning radius B and facing surface C, counterboring at D, turning the outside diameter E, and facing surface F. On the second face of the turret each tool is provided with four cutters, two of which finish-face surface F and the top of rib A; the third tool breaks the corner at the bottom of radius B, and the fourth tool finish-faces surface C at the top of the counterbore.

There is a combination of boring and turning tools on the third turret face which provides for boring hole G, cutting a chamfer at H, and taking a finishing cut on radius B, while a turning tool is finish-turning outside diameter E. Finally, there are two reamers on the fourth turret face which ream holes G in the two pieces of work, while auxiliary tools mounted at this station provide for taking a second finishing cut over radius B and for finish-turning the outside diameter of rib A at the top of the work. For a job of this kind, it will probably be generally conceded that a rate of production running from 180 to 200 of these castings for a ten-hour day is a very satisfactory output.

TABLE FOR THREE-WIRE THREAD MEASUREMENTS

By A. R. McCARTY

The accompanying table contains constants which may be used as a means of simplifying the calculations required when measuring threads of the U. S. form by the three-wire method. The formula for checking the measurement taken over the wires may be found on page 1032 of MACHINERY'S HANDBOOK in connection with which the constants given in the table are to be used. This formula, which is standard, is written

$$M = D - 1.5155P + 3W$$

in which

M = measurement over wires;
D = standard outside diameter of screw;
P = pitch of thread;
W = diameter of wires used.

In this equation the value ($-$ $1.5155P + 3W$) is replaced by a constant taken from the table, which should be added to the standard outside diameter of the screw in order to obtain the measurement over the wires. Thus, when measuring a standard ½-inch screw having 12 threads per inch, the diameter of wire recommended in the table is 0.050, and the constant for this combination is 0.0237 inch which, added to the outside diameter of the screw, gives 0.5237 inch, this being the correct measurement for these conditions. In instances where the recommended wire size cannot be obtained, the value of the constant used may be found by taking three times the difference between the recommended size and the size which is to be used and subtracting it from the constant given for the recommended size, if the wire is below the size given in the table, or by adding it to the constant given if the wire to be used is greater than that given in the table. Thus, for a screw having 10 threads per inch, if a wire 0.065 inch in diameter is used, the difference between this diameter and that of the wire in the table (0.070 inch), multiplied by 3 is 0.015; and this product subtracted from 0.0585 gives 0.0435, which is the correct constant for this size screw thread, using wires 0.005 inch under the recommended size. If the wire had been 0.005 inch greater instead of less than the size given in the table, 0.015 inch would have been added to 0.0585 inch, and the constant would then have been 0.0735 inch. From the foregoing it will be seen that the use of this table will reduce the time required for measuring screw threads by this system.

* * *

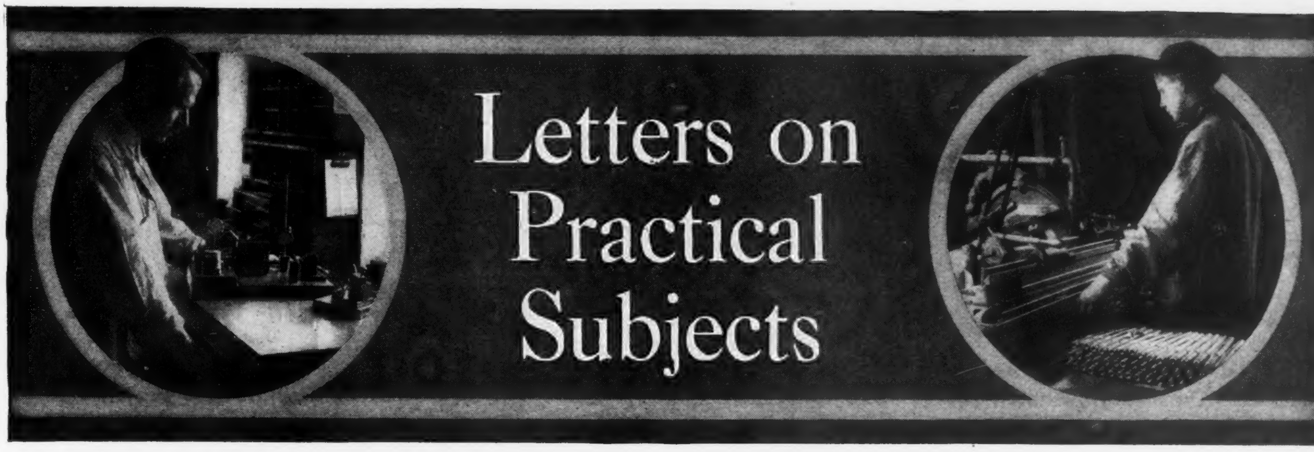
The consolidation of nine steel, coal, and transportation companies of Canada to form a $500,000,000 corporation called the British Steel Corporation is reported; English capital is said to be prominent in the enterprise.

TABLE OF CONSTANTS USED IN MEASURING U. S. FORM THREADS—THREE-WIRE SYSTEM

Micrometer measurement over wires = outside diameter + constant

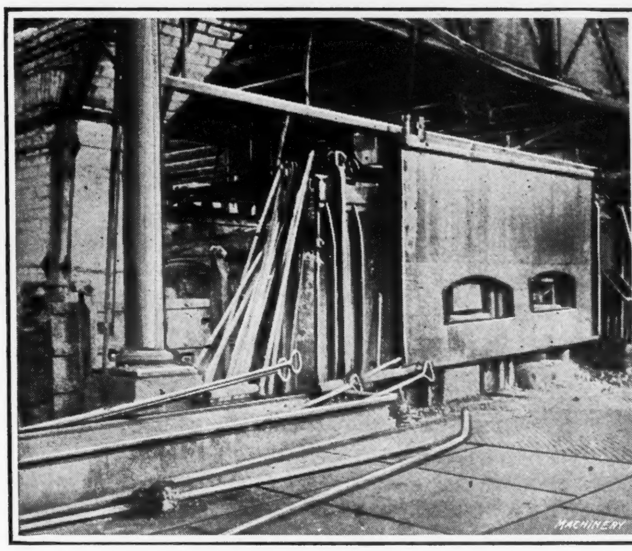
Threads per Inch	Diameter of Wires W, Inch	Constant C, Inch	Threads per Inch	Diameter of Wires W, Inch	Constant C, Inch	Threads per Inch	Diameter of Wires W, Inch	Constant C, Inch
1	0.625	0.3595	7	0.090	0.0535	32	0.025	0.0276
1½	0.500	0.4897	8	0.090	0.0806	34	0.020	0.0154
2	0.3125	0.1798	9	0.070	0.0416	36	0.020	0.0179
2¼	0.3125	0.2639	10	0.070	0.0585	38	0.020	0.0201
2⅜	0.250	0.1119	11	0.070	0.0722	40	0.018	0.0161
2½	0.250	0.1438	12	0.050	0.0237	42	0.016	0.0119
2⅝	0.250	0.1727	13	0.050	0.0334	44	0.015	0.0106
2¾	0.250	0.1989	14	0.050	0.0418	46	0.014	0.0091
2⅞	0.250	0.2229	15	0.050	0.0490	48	0.0135	0.0089
3	0.250	0.2448	16	0.040	0.0253	50	0.013	0.0087
3¼	0.250	0.2837	18	0.040	0.0358	52	0.012	0.0069
3½	0.200	0.1670	20	0.035	0.0292	56	0.012	0.0089
4	0.150	0.0711	22	0.035	0.0361	60	0.011	0.0078
4½	0.150	0.1132	24	0.035	0.0419	64	0.010	0.0063
5	0.150	0.1469	26	0.030	0.0317	68	0.010	0.0077
5½	0.150	0.1745	28	0.030	0.0359	72	0.009	0.0060
6	0.150	0.1974	30	0.030	0.0395	80	0.008	0.0051

Machinery



WATER CURTAIN FOR REHEATING FURNACES

Employers have found it good business policy to provide modern appliances for the safety and comfort of their workmen. Under such conditions an employe can better concentrate his mind and abilities upon his work, and consequently



Water Curtain hung in Front of Furnace Doors as a Protection for the Worker

can turn out more and better work when his mind is not disturbed or his attention diverted by outside influences, such as noise and excessive heat. All such efficiency measures aid in increasing the output, particularly in a shop where their absence is liable to affect the physical condition of the workmen. In rolling mills, the output naturally falls off in the summer, because the intense heat radiated by the furnace is augmented by that of the weather. Various means have been devised to keep the front of the furnaces as cool as possible so that the attendant will be able to maintain a maximum output, or as near maximum as possible.

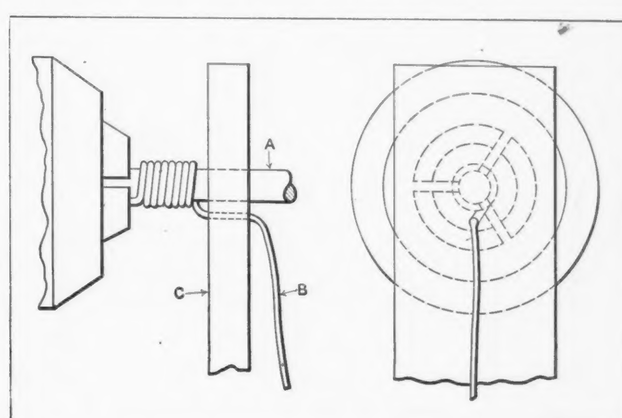
A water curtain such as shown in the illustration is employed in one mill as a protection to the worker. It consists of a rectangular sheet-metal screen suspended by three door hangers mounted on an iron track. Although the appliance illustrated is shown hung in front of a two-door heating furnace, it can be made of the proper size to fit furnaces of various sizes and designs. The oven-shaped openings in the screen are flanged by means of angle-iron, placed around the opening so as to keep the water from flowing into the furnace. A trough having a pipe attached is riveted to the bottom of the screen, and receives the water and conveys it to the trough shown at the left of the screen. At the top of the curtain and extending lengthwise is a spray pipe. The lower side of this pipe is perforated with small drilled holes so that the water is impinged against the sheet-metal screen. The spray pipe is capped at one end and connected with the water supply at the other.

The curtain is not necessary in winter, and may be easily removed by disconnecting the supply pipe and lifting the apparatus off the trolley track. Obviously the streams of running water on the side of the heated screen greatly reduce the temperature and permit the heater to give better attention to his work. In a rolling mill it is absolutely necessary that the billets or blooms be heated uniformly if the desired quality is to be maintained. It is well known that uniform heating of the material is an important factor in the rolling operation and that the output of the mill depends largely upon this condition. If the blooms are heated unevenly and have cold spots on their surfaces, they usually have to be sent back to the furnace after having been run through two passes in the roll, thus delaying the output of the mill. The type of water curtain described is a direct step toward placing the operation of a rolling mill on a more efficient basis. The conditions and methods of working in rolling mills are so different from those in other lines of manufacture that it is a very difficult matter to keep the output up to maximum, because not only the heat in the summer, but also the frost in the winter tends to check the output of the mill.

Youngstown, Ohio W. S. STANDIFORD

WINDING A COMPRESSION SPRING

Small music wire compression springs can be easily made by the method here illustrated and described. Having selected a mandrel *A*, the exact diameter of the interior of the desired spring, and wire *B*, obtain a piece of hard wood *C* (either maple or hickory is suitable), and through this piece of wood bore a hole in which the mandrel will fit, as shown in the illustration. Within 1/32 inch from this hole bore another hole, the size of the wire to be used for the spring.



Method of winding Small Compression Spring

Place the mandrel in the chuck of the lathe, slip the piece of wood over the mandrel, and insert the wire in the smaller hole, pushing it through until its end catches in the jaws of the chuck. Now press the piece of wood against the jaws of the chuck and commence winding the spring, first by pulling on the lathe belt, and then by throwing on the power when the coiling operation is well started. During the winding operation, the piece of wood should be pressed firmly against the coils so that the spring will have the appearance of being close wound. When the completed spring is removed from the mandrel, it will elongate or expand, thus forming a compression spring, that is the size of the mandrel on which it is wound.

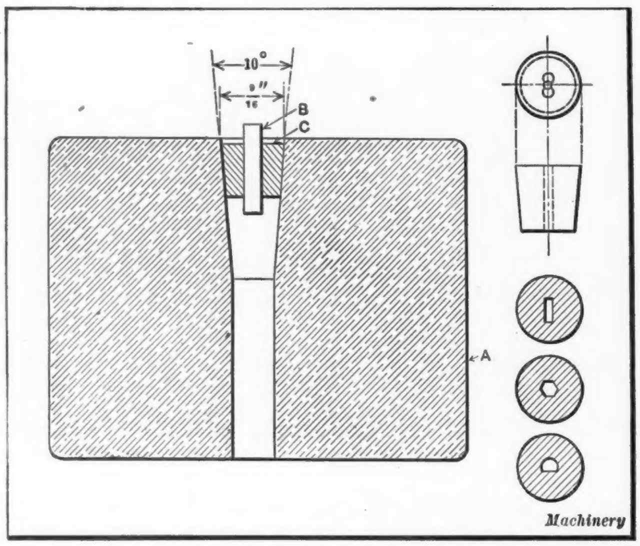
If instead of leading the wire through a small hole as described, a notch is cut in the hole which fits over the mandrel, and the wire fed through this, the inside diameter of the spring will be smaller than the outside diameter of the mandrel. To make the spring a loose fit on the mandrel, the wire should be led through a small hole located at a greater distance from the large hole. If the spring is straightened out by pulling it off from the mandrel, the wire will be badly kinked, but if rewound by the method described, a good spring will be produced. To remove the strains in the wire spring that result from the winding operation, it should be heated carefully, if made from steel, until it is a uniform blue color. If the spring is made of phosphor-bronze or brass wire, it should be covered with tallow or beeswax and heated until it smokes. This will remove the strains so that it will maintain its form. If the heating is done carefully, the spring will be stiffened.

Rochester, N. Y. J. H. BEEBEE

FORMING IRREGULAR-SHAPED HOLES IN DIE-BLOCK BUSHINGS

Die-blocks which are to be provided with irregularly shaped holes may be so made, if the bushed construction is permissible, by employing the following method. Much better results can be obtained by this method than by either filing or broaching and much time can be saved as well.

In brief, this method consists of compressing a bushing, which has been previously drilled through the center, against an inserted arbor of the proper shape until the metal becomes pressed around the arbor, thus forming a hole in the bushing of the required shape. The method of accomplishing this is shown in the illustration, in which a block of steel *A* is shown with the bushing and arbor inserted in a tapered hole. Bushings having holes such as shown in the three small sectional views in the lower right-hand corner of the illustration can readily be produced in this manner. In making a bushing having a rectangular center hole, the center would be drilled out as shown in the upper right-hand corner and an arbor inserted as at *B*. As the pressure is exerted, the tapered bushing *C* is forced down in the hole and the metal compressed around the arbor *B*. This method produces a nicely burnished hole, the exact duplicate of the shape of the arbor. After the hole has been made, the outside of the bushing must, of course, be finished straight so as to be a close fit in the die-block.



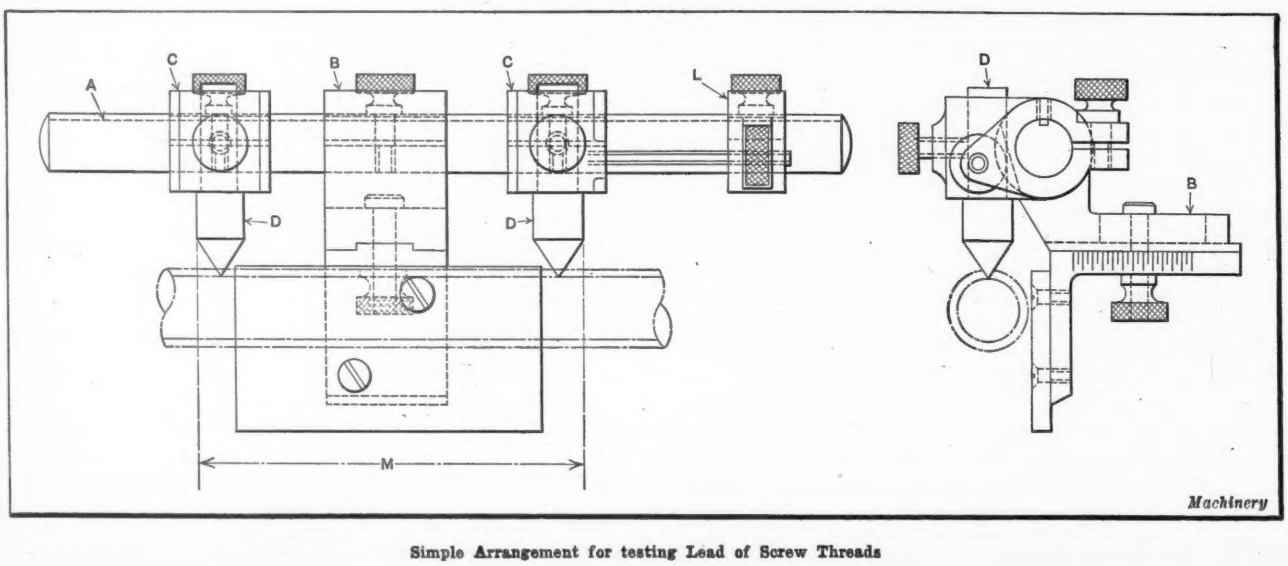
Method of producing Bushings having Holes of Special Shape

Bushings produced by the use of the block shown can be made having holes as large as ⅜ inch in diameter. For larger sizes, it is necessary, of course, to have a larger tapered hole in the block. The practice of bushing the die-block is recommended and should be done wherever possible. In nearly all such cases the method described will be found applicable.

Newark, N. J. JOHN A. SHAND

LEAD TESTING DEVICE

The device shown in the accompanying illustration is a convenient tool for testing the lead of screw threads. It consists of a ⅝-inch round bar *A* having a small splineway cut along its entire length, a back-rest *B*, which is mounted adjustably on a bracket, and two heads *C*, each of which carries a tool-steel test pin *D*. One of these heads is connected with an arrangement for obtaining close adjustments, consisting of a collar *L* secured to the shaft, which carries a knurled nut and a stop-pin as shown. The testing pins are held in the heads by means of small set-screws and can be replaced by pins to suit various thread shapes. The body of the testing pins should be turned true with the measuring points and should be ground to some convenient fractional size within



Simple Arrangement for testing Lead of Screw Threads

close limits, so as to make it easy to calculate the measurement taken over them. The device is used in the following manner: The back-rest is set on the bracket so as to bring the vertical center lines of the pins coincident with the center line of the work. Provision for obtaining this setting is made by graduating the bracket to which the back-rest is attached. The pins are set apart sufficiently to include the entire length of the threads of the piece, the work being held against the bracket, as shown by dotted lines in the end elevation of the illustration. Both pins should be brought into engagement with the thread in such a manner that daylight cannot be detected between the contacting surfaces of the pins and the thread. After the pins have thus been carefully located, a micrometer measurement is taken over the gaging points as indicated at *M* in the illustration. By deducting the diameter of the body of one of the test pins from this reading, the actual lead of the thread is found.

Plainfield, N. J. HENRY DAUT

DRAFTSMAN'S FILLET RULER

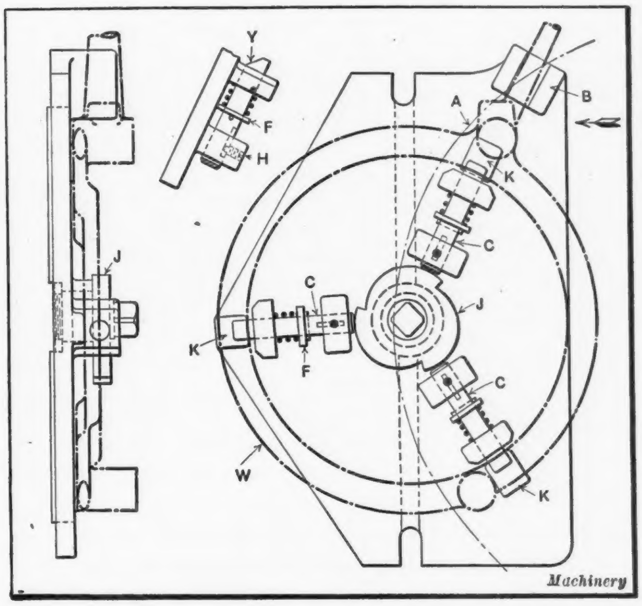
Sometimes a fillet ruler may be used to good advantage by the draftsman when drawing small fillets. Such a ruler may be made from an old photographic film which should be treated in the following manner: First, wash off the sensitized emulsion in hot water, which will leave a clear and transparent piece of celluloid. Then cut to the desired size and, using a pair of sharp dividers or a belt punch, cut circles having radii corresponding to those of the fillets desired. Finally, the holes should be smoothed out with a piece of fine sandpaper, so as to remove all possibility of leaving rough edges. This simply made transparent fillet rule will save considerable time in the drafting-room. Such rules need not be confined to drawing fillets alone, but may be made for drawing hexagonal, oval, or for any other desired shape.

New York City HERBERT M. HILL

MILLING FIXTURE FOR SHIPPER YOKE

Simplicity of operation when it can be obtained without adding prohibitive expense or sacrificing rigidity is always a desirable feature for any fixture. This has been realized in the fixture illustrated, by incorporating three spring plungers and a cam in the design. The work for which this fixture was constructed is a shipper yoke for a drilling machine, which is shown in heavy broken lines as it appears when located on the fixture. This casting has two bosses which are milled in a vertical machine, the idea being to sweep across both bosses with a large surface mill as indicated by line *A*. The table of the machine is fed in the direction indicated by the arrow. The handle portion of the work is located between two lugs *B*, while three plungers *C* are employed to hold the yokes down against the three finished pads *K*. Two of these plungers are located near the bosses, while the third one is placed between them. Two lugs are provided in the base of the fixture for each of these plungers. Between each pair of these lugs, there is located on the plunger a coil spring, the function of which is to operate against the washer *F* for the purpose of withdrawing the plunger from the work as soon as cam *J* has been operated sufficiently to enable this movement to occur. It will be seen that there is a milled slot in the plungers in which the pilot-point set-screw *H* engages for the purpose of preventing them from turning. By this means the beveled surface *Y* on the under side of each plunger forms the proper contact necessary to force the work down against the pads *K*. Any suitable wrench may be employed to turn cam *J* for simultaneously operating the plungers, the effect being to centralize as well as to clamp the work securely in place. The fixture is attached to the table of the milling machine in the regular manner, there being a suitable tongue and two elongated slots provided for this purpose.

H. M.



Cam-operated Milling Fixture for Shipper Yoke

PLANER CHUCK FOR LOCOMOTIVE SHOES

The chucks shown at *A* in Fig. 1, were designed and successfully used in gang planing locomotive shoes. With slight modifications, these chucks have also been found useful in machining other small parts for locomotives. The bodies of chucks *A* are made from either wrought iron or axle steel and are provided with inserted jaws *B*. These jaws are preferably made from tool steel and are hardened, grooves or serrations being cut across the gripping faces previous to the hardening operation. When employed for holding locomotive shoes, the grooved sides of the jaws are made to angles of 8 and 3 degrees, respectively, in order to conform to the shape of the shoes. A tongue planed on the base of the chucks to fit the groove in the planer bed serves to align and hold them in position when locating the work. When several pieces of work *C* are located, the nut at the end of the draw-bolt *D* is tightened, thereby clamping them together. Bolts *E* are primarily employed to hold the chucks to the planer bed. However, should the work buckle when bolt *D* is operated, these clamping bolts will, when tightened, increase the gripping power of the jaws.

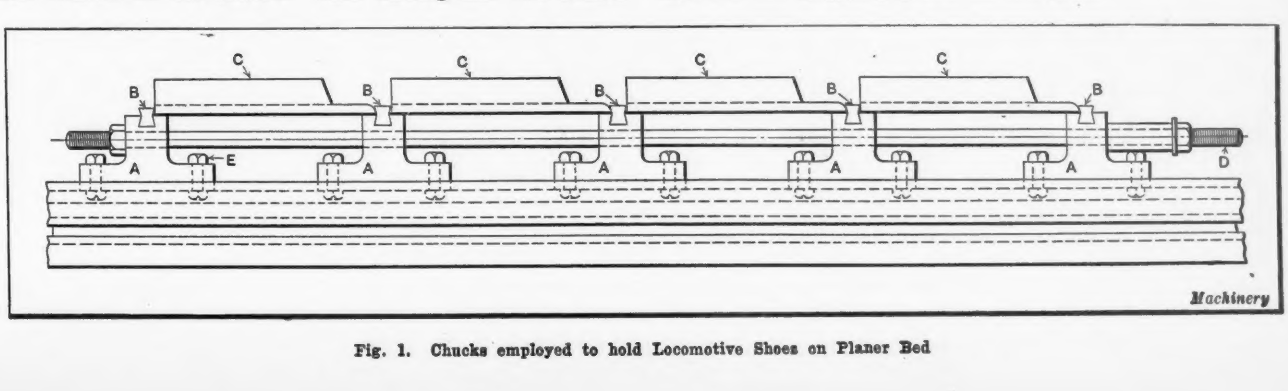


Fig. 1. Chucks employed to hold Locomotive Shoes on Planer Bed

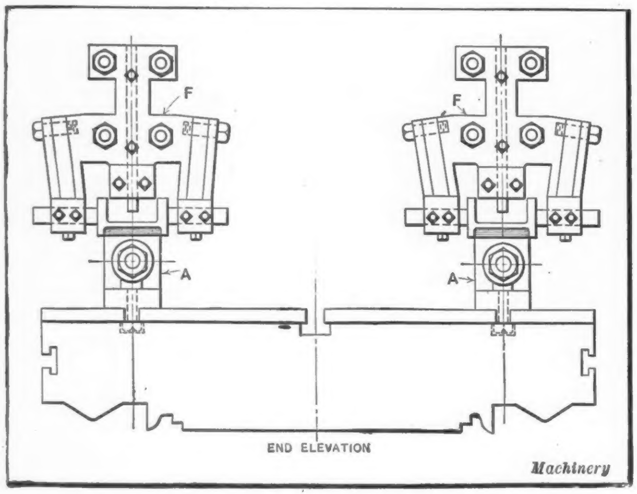
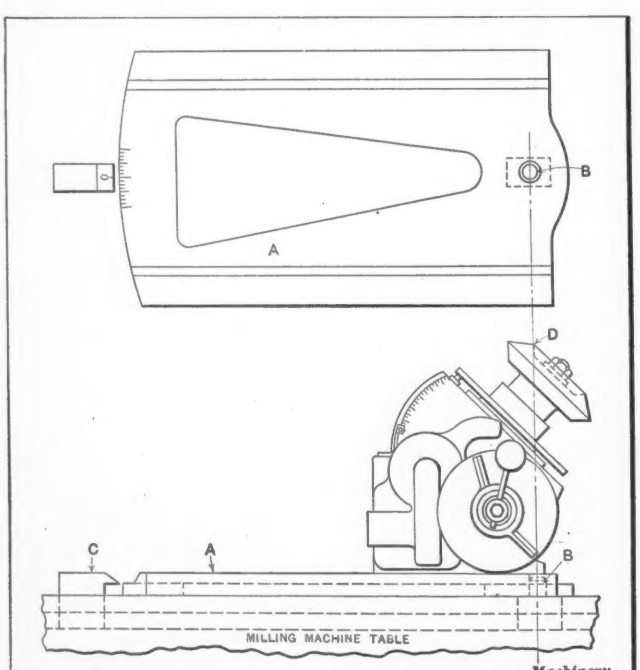


Fig. 2. Tool-holders for gang-planing Locomotive Shoes

The end elevation, Fig. 2, shows the method of mounting two rows of chucks on the planer bed. The special tool-holders *F* are employed when planing the shoes. These tool-holders are bolted to the cross-heads of the machine and have provision for throwing the side tools up out of the way while planing the trough of the shoes. While only four pieces of work are shown in Fig. 1, there is no reason why more could not be held in each row provided the length of the planer bed is sufficient to accommodate them. The chuck and tool-holder described were designed by Timothy C. Foley of Renovo, Pa., and arrangements are being made to have them patented. NORMAN MCCLEOD

METHOD OF CUTTING BEVEL GEARS

The method of cutting bevel gears on a universal milling machine here described was seen by the writer in a railroad shop, and he has since made use of it with satisfactory results in the machine shop of a technical high school. It may prove of interest to others engaged in similar work. The method requires the use of a plate *A* shown in the accompanying illustration. The dividing head is mounted on this plate so that the plate and dividing head can be pivoted about pin *B*, which is fitted snugly into the slot of the machine table, as shown. The opposite end of the plate is graduated so that when set at zero it will be parallel with the table. Sixteenth-inch graduations are marked on each side



Dividing Head mounted on Special Plate used in cutting Bevel Gears

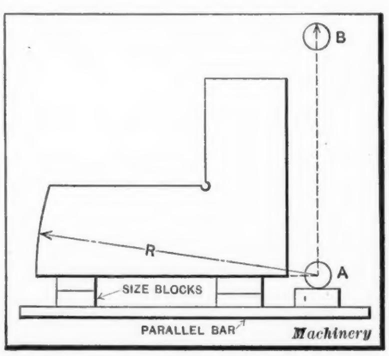
of the center line. The index-finger *C* is fitted in the table slot as shown. With the arbor of the dividing head at the proper angle, and a cutter the exact width of the tooth space at the inner end, the head is moved along the plate until the inner end of the bevel on the gear blank is directly over the center line of the pivot pin *B* as shown at *D* in the illustration. Two cuts are taken producing one unfinished tooth, after which plate *A* is swung to the right and left, respectively, about pivot *B* for trial cuts until the outer end of the tooth is cut to the correct width.

Having carefully noted the graduation at the left-hand end of the plate, all the teeth can now be cut alike by taking cuts with the plate swung the proper amount, as determined by the graduation reading obtained at the trial cuts. Should the cutter be thinner than the correct width of tooth space at the inner end, the dividing head must be moved slightly to the left of the center line of the pivot, thus allowing the inner end of the tooth to swing off center for the trial cuts.

Winnipeg, Canada W. K. MULOCK

TESTING THE RADIUS OF CURVATURE OF A GAGE

To test the radius of curvature *R* of a gage and also the location of the center of curvature, set up for the test as shown in the accompanying diagram. The center from which a given radius is generated quite often bears a certain relation to some working face of the gage, and the location of this center must be tested, as well as the radius.



Set-up for testing Radius of Curvature

Clamp a parallel bar near the edge of a surface plate and secure the disk *A* at some convenient distance from the parallel bar. Then clamp disk *B* so that the measurement taken from the extreme outside of disk *B* to the center of disk *A* will be equal to the desired radius. An indicator may be then swung from *A* by means of a V-block and an arm or bar clamped to it, the indicator being set so as to register zero at the extreme outside of disk *B*. Set the gage the correct distance from the parallel bar, so that the horizontal center line of the disk *A* will coincide with the surface upon which the gage rests, as shown in the sketch. Now set the indicator which is swung from *A*, so that it will bear on the curved surface of the gage, and adjust the position of the gage parallel with the parallel bar, until the indicator registers the same as it does when swung over the reference disk *B*. Finally, swing the indicator back and forth over the curved surface of the gage, and if any deviation from the correct radius exists the indicator will show it. It will also indicate whatever error there is in the position of the center of curvature.

Richmond College, Va. V. E. AYRE

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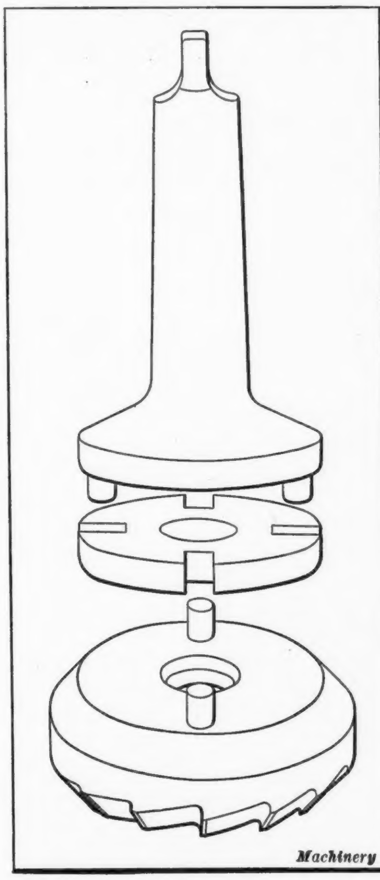
The question of whether the age of aluminum is to follow the age of iron is raised by *Industrial Management*. Our knowledge of bronze, iron, and steel is the heritage of the race, says this journal, for men have fashioned implements from these metals for generations. But aluminum belongs to this generation, and already we have alloys which equal mild steel in strength at the same time preserving that important property of aluminum—lightness. A recently discovered alloy has the property of responding to heat-treatment whereby its strength is greatly increased; as it can also be hot rolled, stamped, and forged it is adaptable to construction.

SHOP AND DRAFTING-ROOM KINKS

FLOATING COUNTERSINKS

In countersinking the edges of cylinder holes in airplane motor crankcases, much time is consumed in attempting to align the spindle with the center of the hole when the work is performed on a radial drilling machine. It is necessary that accurate alignment be attained, as otherwise poor work will result. The floating countersink shown in the accompanying illustration was used in this operation as a means of saving time in aligning the tool with the work. This tool will take care of the alignment regardless of the carelessness of the operator, and in addition will result in a considerable saving of time. The pins in the upper and lower members of the tool engage the four slots located 90 degrees apart on the periphery of the center piece, and give a positive drive even when the center of the lower member is ¼ inch out of line with the shank of the tool. A special shouldered machine screw holds the part together, being tapped into the shank from underneath. If desired, inserted steel bits may be used in place of the solid piece in the cutter. The tool may also be made with a pilot—a construction which is to be recommended wherever practicable. The construction might further be improved by making the pins with flat or slabbed sides where they engage the sides of the slots.



Floating Type of Countersink with Intermediate Driver

Rochester, N. Y. GEORGE C. HANNEMAN

REDESIGNING JOURNAL BRASSES TO FACILITATE MACHINING

The writer desires to call the attention particularly of draftsmen and machine designers to a simple change in the patterns for journal bearing brasses which will, in some cases, greatly facilitate the machining and finishing of these parts. In the shop where the writer is employed, a large number of machines are made with interchangeable journal brasses which require frequent renewal on account of the very heavy duty imposed upon them. These journals range in size from 3 to 10 inches in diameter. It had been the common practice to bore these brasses in pairs, but on account of the narrowness of the casting at *A*, as shown in the accompanying illustration, it was necessary to complete the machining operations on each half separately. Recently one of these machines was given a complete overhauling and among other changes that were made was the enlarging of the recess for the brasses to the size indicated by dimension *B*. This permitted the thin sections of the brasses to be increased in thickness to such an extent that they are now cast in pairs, gated or tied together, as shown by the wall or connecting portion at *D*. The two halves are thus held rigidly together while being bored and finished, after which they are separated by cutting away the joining metal with a hacksaw. It is often possible to effect a saving in time in machining castings for various parts, by giving attention to this point in designing the patterns.

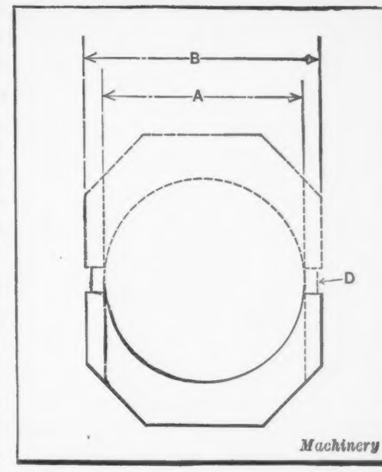
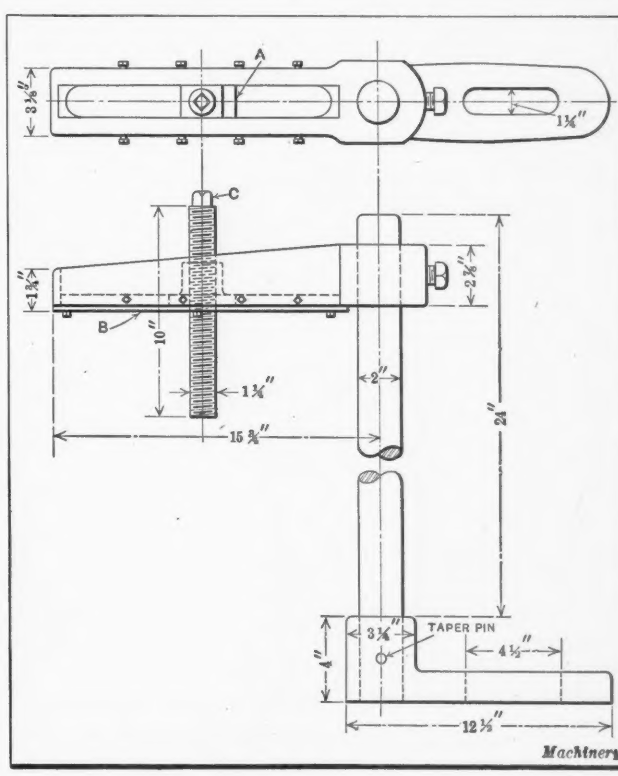


Diagram showing how Journal Brasses were redesigned to facilitate machining

Kenosha, Wis. M. E. DUGGAN

ARM FOR RATCHET DRILL

The accompanying illustration shows a special design of arm for the post of an "old man," which has a recess in which a special square-threaded nut is fitted, as shown at *A*. This recess is 7/16 inch deep and 13½ inches long and is covered by a plate *B*, which encloses the nut. The screw *C* operates in this nut for the purpose of holding the ratchet drill in a vertical position. An arm of this design provides a liberal radial adjustment. The cost of manufacturing this type of "old man" is about $8. NORMAN MCCLEOD



Improved Radial Arm for "Old Man" for Ratchet Drill

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

PROBLEM IN MENSURATION

ANSWERED BY C. N. PICKWORTH, MANCHESTER, ENG.

The problem is to find the diameter of a circular disk which will be tangent to the surfaces *ME*, *MN*, and the point *K* of a gage-block. The known values are the height *a* of the block and the dimension *b*, as shown in the accompanying diagram. Previous solutions to this problem have appeared in MACHINERY which have required the solution of quadratic equations, squaring of binomials, etc., whereas the solution here submitted is very simple and should be handled by the average toolmaker without difficulty.

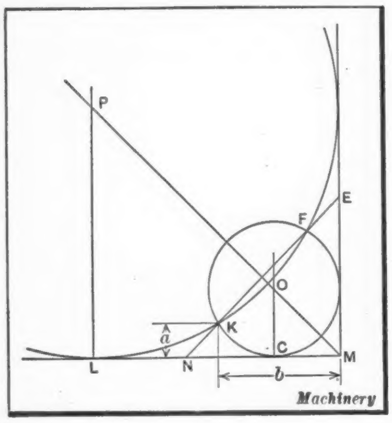


Diagram used in Solution of Mensuration Problem

Through point *K* draw *NE* at 45 degrees from surface *NM*. $KE = b\sqrt{2}$, and $NK = a\sqrt{2}$. It follows then that, since $KE = NF$,

$$NC = \sqrt{b\sqrt{2} \times a\sqrt{2}} = \sqrt{2ab}$$

If, as in the previous examples, $a = \frac{1}{4}$ inch and $b = 1$ inch, then

$$NC = \sqrt{0.5} = 0.707106 \text{ inch}$$
$$CM = 1.25 - 0.707106 = 0.542894 \text{ inch}$$

This is the required radius for a disk which is tangent at the outside of point *K*, but there is another condition of this problem in which the disk touches the required surfaces and also passes through the point *K* as shown by the larger arc in the diagram. This may be found by laying off *NL* equal to *NC* and erecting perpendiculars at both points *L* and *C* as shown. Then by passing a 45-degree diagonal from point *M* through these perpendiculars, the intersection with each will be the center of the required disks. The radius, then, of the large disk may be simply found by multiplying *NC* by 2 and adding *CM*. That is,

$$PL = 2 \times 0.707106 + 0.542894 = 1.957106 \text{ inches}$$

MEANING OF TERMS "FLASH POINT" AND "FIRE POINT"

G. H.—What is meant by the terms "flash point" and "fire point," as applied to oil?

A.—The flash point of oil is the lowest temperature at which the vapor will ignite or flash up momentarily without setting fire to the oil. If the temperature of the oil is increased beyond the flash point, the vapor is given off so rapidly that it will maintain a continuous flame, and the fire point is the lowest temperature at which the oil will burn continuously. The temperatures for the flash point and the fire point may be practically the same for some oils and 20 degrees apart in other oils.

CAST STEEL

R. A.—Cutting tools are sometimes marked "cast steel." Do the terms "cast steel" and "tool steel" mean the same?

A.—The term "cast steel" is sometimes used to designate what is known as tool steel or crucible steel, but this usage is becoming more and more obsolete and should be discontinued, as it is confusing. Steel castings made by pouring molten steel into suitable molds are sometimes referred to as cast steel, but the latter term should not be applied to the high-carbon steel which is made by the crucible or electric processes and is suitable for cutting tools.

COMPARATIVE USE OF BESSEMER AND OPEN-HEARTH STEELS

T. O. R.—Is open-hearth steel used much more extensively at the present time than Bessemer steel? If so, when did this change in practice occur?

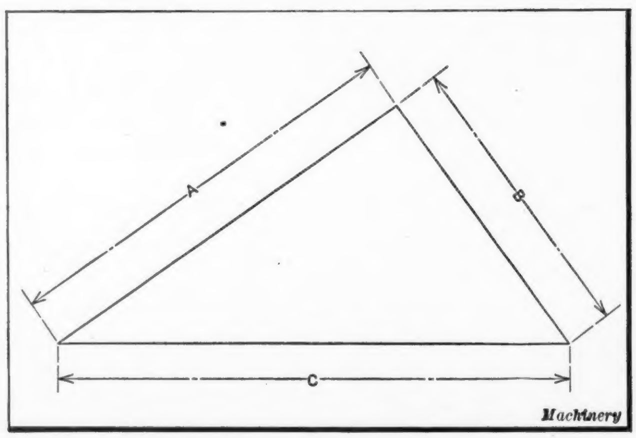
A.—Most of the steel used at the present time is made by the open-hearth process. The tonnages of the Bessemer and open-hearth processes were about equal in the United States in 1907, but in 1912 the open-hearth furnace produced approximately twice as much steel as the Bessemer converter and since then the open-hearth process has been gaining steadily. Better grades of structural steel are made in the open-hearth furnace, and the process produces a more uniform and reliable steel than the Bessemer, as the operations are under better control.

SIMPLE FORMULA FOR FINDING AREA OF TRIANGLE

A. L.—Is there a simple formula which may be used to find the area of a triangle when the only known values are the lengths of the three sides? A formula which involves only simple arithmetic is desired.

ANSWERED BY F. C. MASON, CLEVELAND, OHIO

The formula stated below, which is not commonly found in text-books, may be readily employed by those not familiar with the use of mathematics such as commonly required in



formulas for finding the area of a triangle. Aside from the simple arithmetical operations of multiplication, addition, and subtraction, the only other work required in the solution is the extracting of a square root. The formula is given in the following

$$\text{Area} = \sqrt{S\ (S - A)\ (S - B)\ (S - C)}$$

In this equation $S = \frac{1}{2}$ the sum of the sides *A*, *B*, and *C* (see accompanying diagram). As an example, let $A = 9$ inches, $B = 6$ inches, and $C = 11\frac{1}{2}$ inches. Then one-half the sum of these three is $S = 13\frac{1}{4}$ inches. Substituting in the formula:

$$\text{Area} = \sqrt{13\frac{1}{4} \times 4\frac{1}{4} \times 7\frac{1}{4} \times 1\frac{3}{4}} = 26.73 \text{ sq. in. approx.}$$

The German Machine Tool Industry

From MACHINERY'S Special Correspondent

Berlin, June 7

THE German machine industry has many difficulties to contend with. There has been an immense increase in the prices of all raw materials. Production has decreased due to shorter working hours and lessened efficiency on the part of the workers. As a result, a large amount of capital must be tied up in raw materials and semi-finished parts. The upward tendency of prices for materials, due mainly to increased wages, has not yet come to a standstill. While it is true that the selling prices for machine tools have also increased proportionately, a long time elapses between the time of buying the raw materials at the increased prices and the selling of the completed machine. For this reason, most of the machine building firms have increased their capital and must doubtless make further increases in the future. As examples may be mentioned that the Sächsische Maschinenfabrik, formerly Richard Hartmann, has increased its capital from 15,000,000 to 30,000,000 marks. The firm of Siemens & Halske has increased its capital to 126,000,000 marks, and the Allgemeine Elektrizitäts Gesellschaft has increased its capital from 225,000,000 to 300,000,000 marks. Of this increase it is said that 25,000,000 marks was taken by American financiers, who paid in dollars at the exchange rate at the time this arrangement was made (50 marks to $1). Increases in capitalization and consolidations of firms are the features of the day.

News of the German Machine Tool Industry

The firm of Otto Wolff of Cologne, dealer in iron and steel, has acquired a large interest in the Düsseldorfer Maschinenfabrik, formerly Schiess Aktiengesellschaft. Another iron and steel firm, the Rheinstahl & Phönix, has become the owner of three machine building concerns, Klingelhoeffer, G. m. b. H., of Grevenbroich, de Fries & Co., of Düsseldorf, and the Internationalen Bohrgesellschaft of Erkelenz. These plants will be organized along modern lines with proper standardization and specialization, and will divide between themselves the building of heavy and light machine tools.

There is a tendency to greater specialization in the machine tool industry in Germany. The Union Works of Chemnitz and the firm of Karl Wetzel of Gera, who are both manufacturing horizontal boring machines, have agreed that each firm will build only certain types in the future. The Union shops will build the smaller sizes in two types, and Karl Wetzel will build the larger sizes in two types. The two leading makers of magnetic chucks have made a similar arrangement. Makers of molding machines have also entered into an agreement whereby five of the more important firms will employ a common sales organization under the name of Giessereimaschinen Gesellschaft m. b. H. The individual companies in the combination will merely take care of the manufacture, each specializing on certain types.

A large company for the manufacture of agricultural machinery has been formed, known as the Delma Deutsche Landwirtschaftsmaschinen A. G. Twenty-five machine building firms as well as one hundred landowners are the founders and owners of this company. The capital is 10,000,000 marks, which it is expected will be doubled shortly.

The Exhibition at Leipzig

The success of the exhibition at Leipzig in the early part of the spring was interfered with by the street fighting and rioting which took place in the city. Nevertheless, it is stated that machines were sold to an amount of several hundred million marks. The German machine tool builders' exhibition formed the most important part of the engineering side of the fair. Since the show in 1902 at Düsseldorf, no other machine tool exposition in Germany has been as impressive as that at Leipzig this year. It took four months of intensive work on the part of the German machine tool builders' association to arrange for a successful exhibition. Three hundred and forty firms who build machines for the metal-working trade were represented, and in addition seventy-five woodworking machinery firms had exhibits. There were also over one hundred concerns manufacturing precision tools and small tools. On account of the difficulties in the transportation facilities in Germany, only smaller and medium-sized machines were exhibited. The machines exhibited give an accurate indication of the present tendencies in German machine tool design, and some of the details relating to these tendencies will therefore be given.

Types of Lathes Exhibited

The majority of the lathes exhibited had cone pulley drives. The points emphasized were that in the design care had been taken to place feed-levers, handles, etc., within easy reach. One machine exhibited by Heidenreich & Harbeck of Hamburg had all handles required for operating the entire machine placed in the apron. The same firm also exhibited a lathe of a type similar to the "Lo-swing" lathe built in America.

Turret lathes were exhibited by Pittler and Carl Hasse & Wrede, as well as by the Magdeburger Werkzeugmaschinenfabrik; the latter showed turret lathes provided with from eight to ten roughing tools working simultaneously, special multiple tool-holders being used. These machines proved very efficient and had a high rate of production.

Automatic Screw Machines

The various types of automatic screw machines formerly imported into Germany from the United States are now being built by German firms. The design in general follows the American model closely, although in various details new features may be observed. Hahn & Kolb and Ludwig Loewe exhibited small automatic machines of the Brown & Sharpe type; Alfred H. Schütte had on exhibition a large multiple-spindle automatic, while Gebrüder Böhringer, Carl Hasse & Wrede, and Heidenreich & Harbeck showed automatic machines of the Gridley type. In these machines the drive had been changed, a single-pulley drive with gear-box being employed. It is stated that two other German firms are preparing to manufacture machines of the Gridley type. It is also said that the German automatic machines of this type are built in a heavier design than the American machines, as they are used on castings of tougher composition than those ordinarily employed in the United States. Various new features in design have been introduced, among others an automatic speed selection, whereby the cutting speed best suited for each cut is introduced. The automatic machine shown by Pittler at the exposition is of the Cleveland type, while a machine was shown by Carl Hasse & Wrede which was somewhat different from the well-known types.

Other Classes of Machine Tools Exhibited

Fritz Werner, Ltd., of Berlin-Marienfelde exhibited new grinding machines—among others a grinder spindle made originally for the Fortunawerke at Cannstatt, which runs at

60,000 revolutions per minute. Fontaine exhibited a die-grinder, particularly interesting on account of its size.

In the field of planers and shapers there has been remarkable progress in specialization. The Samsonwerke exhibited a new shaper having many original features. The planers exhibited were well designed and indicated attention to detail. In the boring and drilling machine group more compact designs and increased dimensions of columns were noticeable. The Titaniawerke exhibited a drilling machine with box column, and in general there is a tendency to design columns or frames of very strong construction.

Some heavy punching machines were exhibited by the Berlin-Erfurter Maschinenfabrik, but on the whole only the smaller machine tools have survived from the war industry and passed into the peace-time industries. Some milling machines designed originally by the Titaniawerke for the manufacture of fuses for projectiles have been redesigned to suit the needs of the machine building trade in general.

The Small Tool Industry in Germany

The small tool industry was well represented at the Leipzig Fair. Tools of various descriptions, milling cutters, drills, reamers and chucks were exhibited by first-class makers. Of particular interest was the group of measuring instruments exhibited by Hirth & Zeiss, possessing features of great interest, and opinions were expressed that in regard to measuring tools, the German industry has reached American quality, and in many cases surpasses in original design. Zeiss of Jena, in particular, exhibited many new tools of great interest, including new optical measuring and testing appliances, a new microscope for measuring threads, micrometers, etc. It was evident that the physical laboratory methods of scientific measurements have had a distinct influence on the design of measuring instruments used directly in the machine building industries.

* * *

ILLINOIS MANUFACTURERS ON THE BASIS OF WAGES

The Illinois Manufacturers' Association has submitted to the United States Railroad Labor Board a brief in which the following very important points are made:

The practice of basing wages on the cost of living, without taking into account the work performed for the wages, is at the very bottom of the present disturbed and unsatisfactory labor conditions. It is usual now, in presenting claims for wage advances, to attach an estimated family budget, upon which the percentage of wage increase is predicated. Unfortunately this family budget is presented only to further the claims of a particular body, but a universal application of the budget presented might lead to impossible economic results. If, for instance, the figures submitted by Mr. Lauck that $1700 represents the lowest subsistence level and $2500 the lowest comfort level for an American family were accepted, and the scale of wages in the transportation service were based on the assumption that every man engaged in this service, no matter where he lives, whether married or single, is entitled to a wage based on a scale with those figures as minimum, would it not be fair to assume that every wage earner in every part of the country is entitled to a scale based on that same minimum?

"From our experience as manufacturers," says the Illinois Manufacturers' Association, "we should say that if Mr. Lauck's budget were made the basis of a universal demand, the farms, the mines, and the industries would be wholly unable to meet it on a straight time basis." The Railroad Labor Board, therefore, can render a signal service to the country by indicating to these claimants that while wages should be equalized in those cases that have lagged behind in the wage readjustment, wages cannot be *paid* unless they are *earned*, and that we cannot get more out of the common pot than we put into it.

The divorce of wages from production has been one of the calamities of the war, for it has created in the mind of the wage earner, the delusion that irrespective of output, performance, or character of service rendered, he is entitled to live on a certain scale. Statisticians spend their time in developing elaborated lists of family requirements, instead of determining how wage increases based on these requirements can be paid. And so it happens that during the most critical time in the industrial history of the country, when the consumption of commodities has expanded, and world production of commodities has been greatly impaired, there has been established a shorter working day, piece and premium forms of payment have been abolished in many instances, and the worker has the idea that he is entitled to a good living irrespective of how much he produces.

The time has come when it is necessary to emphasize the necessity that part, at least, of the increased cost of living shall be met by longer hours and increased output, and that piece and premium rates of pay should be re-established.

* * *

THE FEDERATED AMERICAN ENGINEERING SOCIETIES

Delegates representing sixty-one national, regional, state and local engineering and technical societies of the country attended the conference held at Washington, D. C., on June 3 and 4, for the purpose of effecting an affiliation of these bodies. The constitution and by-laws presented to the conference were favorably voted upon by forty-nine societies, the remaining societies either not voting or being absent from the meeting. Representatives of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, who were empowered to take such action for their respective societies, ratified the constitution and by-laws. A similar action could not be taken by the remaining societies represented at the conference because their delegates were not empowered to act, and a ratification must later be made by each society desiring to become a member of the organization. The constitution provides that the name of this association of societies shall be the "Federated American Engineering Societies." The work of promoting the interests of the organization until it can become active was entrusted to the Engineering Council.

The object of the federation is to further the interests of the public through the use of technical knowledge and engineering experience, and to consider and act upon matters common to the engineering and allied technical professions. The management of the organization will consist of a body known as the "American Engineering Council," which will act through its executive board. Each national, regional, state, and local organization will be entitled to one representative on the council for a membership of from 100 to 1000 inclusive, and one additional representative for every additional 1000 members or major fraction thereof, but no organization can have over twenty members on the council. Meetings of the council will be held annually, although special meetings can be held at any time upon the request of twenty-five of its members. The functions of the council are to coordinate the activities of state councils and local affiliations whenever these activities are of national or general importance or may affect the general interests of engineers. The executive board will consist of the six officers of the council and twenty-four of its members.

Resolutions were adopted advocating the payment of adequate salaries to teachers of engineering in technical institutions, and the adoption of appropriate measures to give effect to the recommendations recently made to Congress for a more adequate salary schedule for engineering and other technical services of the Federal Government, and indorsing the bill now under consideration by Congress, for the creation of a Department of Public Works.

Spring Meeting of the American Society of Mechanical Engineers

AT the spring meeting of the American Society of Mechanical Engineers held in St. Louis, Mo., May 24 to 28, a great number of important papers relating to mechanical engineering subjects were read, particular attention being given to engineering problems affecting industries of the Middle Western states. Six specific sessions were held, devoted to appraisal and valuation, aeronautics, foundry practice, power and combustion, and general mechanical engineering science, and a local session with papers presented by St. Louis engineers. The papers most important to the machine-building field are briefly reviewed in the following.

Tight-fitting Threads for Bolts and Nuts

A paper on this subject was presented by Chester B. Lord of St. Louis, Mo., who stated that although in general the thread forms now in use are quite satisfactory, perfection has by no means been reached. There is still considerable search for "a thread that will not loosen," and in the preliminary portion of the paper, the author discussed the fundamental principles involved in the manufacture of threads. The problem to be solved, he stated, is as follows: "Without sacrifice of strength, without increase of rejection, without additional manufacturing costs, find a method whereby a male and female thread of the same lead and pitch diameter may be made after repeated loosenings to fit right without the aid of a locking device." The reasons for departing from accepted practice were presented and discussed, and as a result of experimental work, the author drew the following conclusions: (1) The cause of stripped threads is lack of room into which the metal can flow; (2) the pitch diameter should be the same in both threads; (3) the lead should be the same; (4) the thread angle should differ by not more than 10 degrees; (5) the limits for the inside diameter of nut need not be adhered to closely, as the inner part of the nut thread holds very little, if any; (6) the outside diameter of plug and pitch diameter of both plug and nut are important and should be adhered to fairly closely.

Malleable Castings

In this paper Enrique Touceda of Albany, N. Y., stated that malleable castings are now regularly made weighing as much as 500 pounds, with an ultimate strength of 50,000 pounds per square inch and an elongation of 10 per cent or over. With these properties in mind he compared such castings with gray iron and steel castings, showing that with respect to the former the malleable casting has equal physical properties, costs no more, is lighter in weight and is not liable to breakage. More than 70 per cent of the steel castings produced in this country are not annealed and are in a state of internal strain. Annealed malleable castings are free from such strain, are less expensive to produce, and in the author's opinion will stand more abuse in service. Their use is therefore recommended for any part of such size as can be successfully made where strength combined with ductility and low cost per pound is essential.

Die-castings

A paper on die-castings was presented by Charles Pack, of Brooklyn, N. Y., in which he stated that the die-casting process is best adapted to alloys of comparatively low fusing points, such as those of zinc, tin, lead, and aluminum. While it is stated that no general rules can be laid down governing the design and application of die-castings, the paper nevertheless outlines the general properties of the various alloys used and their fields of application, and gives particulars regarding such limitations as maximum weight of casting, minimum wall thickness, minimum number of threads, and minimum diameter of holes that can be cast, draft for cores and side walls, etc.

Aluminum Castings

A paper on aluminum castings by Zay Jeffries of Cleveland, Ohio, first gave particulars of the various aluminum alloys used for casting purposes. The metallography and physical properties of these alloys were then dealt with, following which information was given on maximum and minimum weights, tolerances on dimensions, and machining data. Later sections dealt, respectively, with heat-treatment, aging, effect of thickness of section and rate of chill on physical properties of aluminum alloys, fatigue resistance, special places where the use of aluminum castings is indicated by reason of their lightness and ease of machining, and with the selection of alloys for special purposes.

Steel Castings

The paper on steel castings was prepared by John H. Hall of High Bridge, N. J. This paper dealt briefly with the physical properties of steel castings and their improvement through annealing and heat-treatment, cost of castings, and the classes of work for which steel castings should be specified. Castings are now made, it is stated, with physical properties nearly twice as good as those of the ordinary commercial product, and where the service demands unusual strength, toughness, and resistance to wear and fatigue, their use is urged even though they machine somewhat less freely.

Gray Iron Castings

In a paper on gray iron castings, Richard Moldenke, of Watchung, N. J., dealt briefly with the chemical composition of gray iron castings, giving in this connection a table of recommended compositions for many varied purposes. He then indicated the extent to which specialization has taken place in iron founding and enumerated the various classes of foundries and the lines of work to which they are best adapted. Dealing with recent tendencies in gray iron foundry practice, he called attention to the very high sulphur content now met with in castings—a result of the use of abnormal proportions of scrap during the war because of the high price of pig iron—and gave brief particulars of an economical duplexing process by means of which the sulphur in molten cupola metal may be brought down in an electric furnace from, say, 0.12 per cent to 0.05 per cent and even lower.

Brass and Bronze Castings

In the paper on brass and bronze castings, Christopher H. Bierbaum, Buffalo, N. Y., after a short discussion regarding the terminology employed in designating alloys of copper tin, zinc, and lead, stated certain precautions that an engineer should take when specifying an alloy for a given service and then dealt briefly with the various deoxidizers and fluxes used in the brass foundry. The latter half of the paper was devoted to an enumeration of the more important bronzes and copper alloys, their compositions, properties, and uses being set forth in considerable detail.

Industrial Housing

A paper on industrial housing was presented by Leslie H. Allen of Springfield, Mass., in which he treated industrial housing as a financial problem. Our housing shortage is said to be due partly to the fear of a financial panic and partly to the fact that rents, high as they are, are not high enough to show an adequate return on present-day construction costs. The relation of rents to capital invested, the calculation of proper rents, and methods of financing house construction were discussed in some detail. The paper closed with a discussion of the scheme of cooperative housing, which the author suggested may be the solution of America's housing problems.

Appraisal and Valuation Methods

This paper, prepared by David H. Ray of Pasadena, Cal., brought out the need of the engineer's entering the appraisal field in the full capacity which his training and experience warrant. The engineer is likely to be more familiar with the cost and value of materials, machines, and structures than the lawyer or accountant, who in the past have been the only ones considered competent to direct this work. The topic of appraisal and valuation is essentially an engineering function, and it is the duty of the engineer to develop, guide, and control the method and procedure. Reports must necessarily depend on the purpose of the valuations and are divided into two main groups, private and public. It is pointed out that the variables affecting values depend on labor, material, and a factor to cover the general risk of the business, with particular reference to marketing. Charts, curves and tabulations were given to show the change in these values during the period of the war, and terms used in appraisal work were defined. The paper further showed the desirability of giving a value to a machine as a unit, of the grouping of similar tools, and of the use of symbols in the form of numbers and letters in tagging the materials to be appraised.

In addition to this paper on appraisal and valuation methods, other papers on kindred subjects were also read as follows: "Price Levels in Relation to Value," by Cecil F. Elmes, Chicago, Ill.; "Data on the Cost of Organizing and Financing a Public Utility Project"; "Rational Valuation," by James Rowland Bibbins, Chicago, Ill.; and "The Construction Period," by H. C. Anderson, Ann Arbor, Mich.

Aeronautical Papers Read before Spring Meeting

Four papers relating to aeronautics were read before the meeting dealing with various phases of mechanical engineering work in aeronautics. These papers were as follows:

"Aeronautic Instruments," by Mayo D. Hersey, Washington, D. C.; "Analytical Theory of Airplanes in Rectilinear Flight, and Calculation of the Maximum Cruising Radius," by A. Rateau, Paris, France; "The Flow of Air through Small Brass Tubes," by T. S. Taylor, Pittsburg, Pa.; and "Physical Basis of Propeller Design," by F. W. Caldwell and E. N. Fales, the latter paper being illustrated by moving pictures.

Power and Combustion Session

At the power and combustion session four papers were presented as follows: "Locomotive Feed-water Heating," by Thomas C. McBride, Philadelphia, Pa.; "Efficiency of Natural Gas Used in Domestic Service," by Robert F. Earhart, Columbus, Ohio; "Pulverized Coal in Metallurgical Furnaces at High Altitudes," by Otis L. McIntyre, New York City; and "A Method for Separation of the Dissolved Gases from Water and Some of Its Uses," by J. R. McDermet, of Greensburg, Pa.

Local Session

At the local session, papers contributed by St. Louis engineers were read. One of these papers was that on "Tight-fitting Threads for Bolts and Nuts," previously reviewed. In addition a paper on "The Housing Problem" was read by Nelson Cunliff, and the following papers were also presented: "Mississippi Valley River Transportation Activities," by E. W. Schadek; "Design of an Ore Fleet for the Upper Mississippi River," by William S. Mitchell; and "Burning Eastern Coals Successfully on a Conveyor-feed Type of Stoker," by Lloyd R. Stowe.

Scientific Session

The scientific session was a joint session of the American Society of Mechanical Engineers, the American Society of Refrigerating Engineers, and the American Society of Heating and Ventilating Engineers, who held their conventions in St. Louis at the same time. M. S. Van Dusen of the American Society of Refrigerating Engineers contributed a paper on "The Thermal Conductivity of Heat Insulators," and in addition the following papers were read: "The Dissipation of Heat by Various Surfaces," by T. S. Taylor, Pittsburg, Pa.; "An Improved Form of Weir for Gaging in Open Channels," by Clemens Herschel, New York City; and "Simplification of Venturi-meter Calculations," by Glenn B. Warren, New York City.

Committee Reports

A number of committee reports were also presented, including a code of safety standards for the construction, operation, and maintenance of elevators and escalators prepared by the American Society of Mechanical Engineers with the assistance of representatives of the U. S. Bureau of Standards, the Elevator Manufacturers Association of the United States, the Elevator Manufacturers Association of New York, the casualty and fire insurance companies, the American Institute of Architects, and various related engineering societies, elevator specialty manufacturers, and independent engineers. A special committee on code of ethics also reported a proposed code.

Machine Shop Practice Section Organized

An important feature of the meeting was the organization of the section on machine shop practice, the purpose of which will be to study the design, construction and operation of metal-working machines, including metal-working tools and appliances. A committee, consisting of Ralph E. Flanders of the Jones & Lamson Machine Co., Springfield, Vt., Forrest E. Cardullo of the G. A. Gray Co., Cincinnati, Ohio, C. V. Lord of the Wagner Electric Mfg. Co., St. Louis, Mo., and Professor H. B. Fairfield of the Worcester Polytechnic Institute, was selected to nominate permanent officers who will be elected by the members of the section.

An inspection trip was arranged to the Commonwealth Steel Co., Granite City, Ill., the plant of which was viewed by the visiting engineers with great interest. The following plants were also visited: Busch-Sulzer Bros. Diesel Engine Co., the Mississippi Valley Iron Co., and the coke plant of the Laclede Gas Light Co.

* * *

MAKING POWER PRESSES SAFE

Safety engineers who have attracted national attention through their effective work in the safeguarding of power presses addressed the conference of the Engineering Section of the National Safety Council at a meeting held in the Auditorium of the Western Society of Engineers in the Monadnock Bldg., Chicago, on June 24. The program of this conference was divided into three sessions, morning, afternoon, and evening. The latter session was based on the subject of safety as it affects production, and was held jointly with the Chicago Safety Council, the Western Society of Engineers, and the Accident Prevention Committee of the Illinois Manufacturers' Association. The information resulting from the meeting will be used in drafting the national safety code on power presses, sponsorship for which has been accepted by the National Safety Council.

Gears from a Purchaser's Standpoint

By D. G. STANBROUGH, General Superintendent, Packard Motor Car Co., Detroit, Mich.

IN a paper read before the American Gear Manufacturers' Association convention at Detroit, which is here reviewed, the author first dealt with questions relating to personnel and organization, labor market, plant buildings and equipment, in so far as these affect the gear manufacturing industry. He next dealt with the fact that satisfactory gears from a purchaser's standpoint can only be produced as a result of conformity to good practice along the following lines: (1) Design; (2) materials; (3) forgings and castings; (4) heat-treatment; (5) machining; (6) hardening; and (7) inspection.

The Importance of Correct Design

There are certain fundamental considerations of design that can be counted upon to produce good gears, although a partially satisfactory product may be turned out if all of these fundamentals are not strictly adhered to. The good features of gears are uniform sections and a tooth form which will meet all the requirements as to strength. The design must also take into consideration the practice of the plant in which the gears are to be manufactured. Take, for instance, the familiar cluster gear used in automobiles. This cluster can be made from the blank with integral gears, or can be made with three integral gears and a fourth gear riveted or fastened to a flange. In the first case, a certain method of cutting has to be employed, and there will be unquestionably a considerable loss from warpage in heat-treatment. In the other case, the loss from warpage is reduced, but on the other hand considerable grinding is introduced and a nice fitting job is necessary. The decision as to the design should naturally rest with the practice of the shop. Good gears can be produced by either method, and the one to be adopted depends more upon which is in vogue than upon any technical consideration as to the results that can be obtained with either method.

Method of Mounting

Another thing which needs careful attention in designing gears, if satisfactory results are to be obtained, is the method of mounting. The best cut gear that can be made will not give satisfaction unless properly mounted. Many a noisy gear would not be noisy if it were run on quiet bearings. The mounting of gears should be such as to take care of the stress incident to the pressure angles. The shafts should be stiff, the mounting rigid, and the bearings as close to the center of the load application as it is possible to make them. In designing a gear-case, strains should receive careful consideration. The manufacturer cannot be expected to turn out a finished product which will conform to the customer's specifications unless the product be given at least fair conditions under which to operate. Much time and energy can be saved by giving more consideration to the design of gear mounting before the manufacturing work is undertaken. Too little attention has been paid to the mounting of gears by designers in the past. The manufacturers can do the purchaser a favor by pointing out the deficiency in design before undertaking contracts.

Materials for Gears

In selecting the materials from which gears should be manufactured, the conditions under which the gears are to be operated should be considered. First, those subjected to practically no stress and very little wear should be made of bronze, cast iron, untreated bar stock, and aluminum. Second, if the service will produce great wear but not severe stresses, the material should be "straight" carbon steel and should be carburized. Third, if the gears are subjected to extreme wear and considerable stresses, they should be made from forgings of alloy steel and should be carburized. Fourth, where severe impact and other stresses are involved with a normal rate of wear, high-grade alloy steel forgings should be used, oil-treated and not carburized. Fifth, where the gears are to be subjected to extreme wear and extreme stresses, they should be made from self-hardening steels which have been forged.

Castings and Forgings

No serious difficulty is encountered when the gear blanks are cast, although it is important to keep the sections uniform in order to guard against shrinkage cracks, especially in the case of gear blanks made from steel castings. With cast iron, it is important, in order to obtain long life, that the combined carbon be high and that the metal be cast so that the blank will be chilled, thereby retaining a sufficient quantity of the carbon in solution. The blanks should not be so hard that they cannot be machined without annealing, the most satisfactory results being obtained with a scleroscope hardness of about 35; the combined carbon content should be between 0.30 and 0.50 per cent. No particular difficulty is experienced with bronze and aluminum castings.

The forging of gear blanks represents a considerable problem. The temperatures at both the beginning and end of the operation should be held within certain well defined limits, according to the forging temperatures of the steels being used. High temperatures produce burnt gears, which sometimes can be used only after an expensive corrective treatment process has been employed. A low finishing temperature results in cold strains which when relieved in heat-treatment reveal cracks, seams, and fissures. Another phase of the forging of gears is in regard to the type of forging machines employed. Generally speaking, the flow lines of the metal in a forging should be at right angles to the forces applied to the gear teeth while in operation. It follows, then, that a gear that is flat can be produced under a drop-hammer, while gears having bosses and those in which length is the predominant feature, can best be produced by a forging machine. The size of the hammer has an important bearing on the subject; a large gear cannot be satisfactorily forged under a light hammer, as the time required to close the dies permits the gear to cool and results in too low a finishing temperature.

Preliminary Heat-treatment

Practically all gears that have been forged should be given a preliminary heat-treatment before machining, particularly those gears that will be subjected to great stress and that must be practically free from distortion after hardening. On mild steel, this initial heat-treatment consists simply of annealing or normalizing. Normalizing the steel eliminates whatever stresses have been set up in the forgings and renders the gears suitable for machining. On the alloy and high-carbon steels, the normalizing treatment is not sufficient. Gear blanks made of these steels are first quenched from a suitable temperature and then drawn sufficiently to enable them to be machined.

Salient Points in the Machining of the Blanks

In manufacturing gear blanks, it is important that the surfaces be held parallel and that they be machined true with the holes in the blanks. In the author's experience, broaching will produce a straighter hole than reaming.

Gears that have splined holes should be machined from the splines, both in the blanking and cutting operations. It is also essential that the pitch line of the gear be concentric with the hole.

Probably the simplest method employed for locating the gears when finish-grinding the bores and faces is the one in which the work is located from the periphery. Another method employed is that in which the gear is located from the root diameter, and still another method and the most difficult of the three, is that by which pins carried in the chuck contact with the gear teeth at the pitch line. Locating a gear from the root diameter is the most practical method. When this practice is followed, it is necessary to finish-cut the root diameter at the same time as the pitch diameter. This method also enables the locating pins in the chuck to be made stationary for each size of gear, which is an advantage. Although the method of locating from the pitch line has given satisfactory results, it is probably just a little less accurate owing to the fact that warpage produced in heat-treatment will have a greater effect at the pitch line than upon the root or at the top of the teeth. Locating the gear from the periphery is open to the objection that greater accuracy is required in the primary operations in order to get satisfactory results. Further difficulties to locating from the periphery arise from the fact that burrs are often thrown up, which if not removed will cause errors.

Final Hardening of Gears

All gears made from carburized stock and, as a rule, all oil-treated gears are finish-machined before final heat-treatment. Although considerable difficulty may be experienced in the final heat-treating process, the "hump" method developed by Leeds & Northrup Co., Philadelphia, Pa., is one of the most satisfactory of the various methods which may be employed. Distortion in gears is dependent to a large degree upon heating. The range of heating, together with the establishment of constant quenching temperatures, can be relied upon to solve problems in gear distortion which formerly were believed to be uncontrollable. To a large measure the solution of these temperature-control problems is due to the development of the electric furnace.

Methods of Testing Gears

After the purchaser has satisfied himself that the various manufacturing conditions required to produce a satisfactory gear have been complied with, attention should be directed to the final inspection process. The hardness test is of much importance, but it should be remembered that tests such as the scleroscope furnishes are comparative only, and that standards of hardness to suit the service to which the gears will be subjected should be established. The limits of these standards should be such that the gear will withstand a reasonable amount of wear, but it should not be so high as to make the gear brittle. The work of inspection, then, so far as hardness is concerned, is to determine whether the gears are within the limits allowed.

After the hardness test, each piece should receive a rigid visual inspection under good lighting conditions, for the purpose of discovering cracks and seams which may develop during the final hardening operation. With reference to inspection of tooth form, a rolling fixture in which the gears are mounted at the correct center distance and rolled with a master gear is recommended. A hand rolling fixture will give better results than a power type. The gears should be tested for backlash and for conformity to the dimensions specified by the established practice of the manufacturer.

* * *

It is reported from Sheffield, England, that production of high-speed steel is unable to keep pace with the demand and that heavy buying, especially from the United States, as well as a great domestic demand will cause an increase in the price. After the armistice, the high-speed steel industry faced a depression, but today the demand exceeds the supply.

NEW BOOK ON GAGE MAKING

GAGE DESIGN AND GAGE MAKING. By Erik Oberg and Franklin D. Jones. 310 pages, 6 by 9 inches; 231 illustrations. Published by The Industrial Press, 140-148 Lafayette St., New York City. Price, $3.

As has often been pointed out, the cost of manufacturing any machine, device, or mechanism may be greatly influenced by the tolerances specified on the parts and by the gages employed in the manufacture and inspection. There is no doubt but that there is still a great deal of misunderstanding with regard to tolerances and their application in the manufacture of machines and mechanisms. The tolerances should be based upon the practical requirements of the mechanism to be made. Unnecessary accuracy which does not improve the working quality of the product merely increases the manufacturing cost. After the tolerances have been established, the gages used for maintaining these tolerances must be so designed that they are not only accurate, but well adapted to shop use. The relation between the gaging system and the design of the jigs and fixtures is also essential.

The book under review deals with such fundamental and vital points as outlined above, and is therefore a valuable addition to the technical literature of today. Briefly, it is a treatise on the development of gaging systems for interchangeable manufacture, covering the design of different types of gages and their production, and dealing in detail with the precision machining operations and lapping processes required in making accurate gages. It also deals with various modern appliances for gage measurements. Much has been published in the past on manufacturing practice, but comparatively little is available in book form on the design and making of gages. This book, in fact, is the first one of its kind dealing with the subject in a comprehensive and systematic manner; and at a time when the mechanical world has fully come to realize that gages should control the different manufacturing processes so that the required degree of interchangeability may be obtained, the book will be received with favor by production engineers, gage designers, and toolmakers.

The scope of the work is best indicated by a general review of its contents. The opening chapter contains a comprehensive review of the various steps required in the development of a gaging system. This is followed by chapters dealing with different types of gages, such as snap and plug gages, contour or profile gages, flush-pin and sliding-bar gages, hole gages, and thread gages. The chapters dealing with these types of gages describe in detail the various points to be considered in designing, and show numerous examples of actual designs.

The next main section of the book contains chapters on the making of different types of gages, especially thread gages, and covers the making of Whitworth thread gages, the grinding and lapping of thread gages, as well as various methods for measuring thread gages, including lead and diameter measurements, microscopic measuring machines for testing the accuracy and contour of thread gages, and an explanation of the projection method of testing gage threads. As a final chapter, a review of general gage-making practice is included dealing with such subjects as steel used for gages, the grinding of snap gages, gage grinding machines, heat-treatment of gages made either from machine or tool steel, restoring worn gages, and other subjects of interest to the gage-maker.

The part of the book dealing with the development of gaging systems and gage design is based largely upon the experience and practice of the Pratt & Whitney Co. in making gaging equipment for small arms and heavy ordnance. This company has done a great pioneer work along these lines, and the principles established during the war have in this manner been made available for the production of tools and machines used in peace-time pursuits.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

Niles-Bement-Pond Radial Drilling Machines

Radial drilling machines of this type are built in 5- and 6-foot sizes, and in both plain and universal styles. They may be driven by 4 to 1 variable-speed motors, with provision for reversing the direction of rotation for performing tapping operations. Eight changes of feed are available, covering a range of from 0.006 to 0.060 inch per spindle revolution. With variable-speed motor drive, there are twenty-eight available speeds, ranging from 20 to 400 revolutions per minute. A constant-speed driving motor may also be utilized with a gear-box for obtaining speed changes. With this equipment there are sixteen available speeds, covering a range of from 13 to 452 revolutions per minute. A number of noteworthy departures from standard practice have been made in designing these machines, and the more important of these unusual features are fully described.

SEVERAL noteworthy departures from established practice in the construction of radial drilling machines have been made in working out the design of the tools which form the subject of this article. They are known as "right line" radial drilling machines and are built in both plain and universal types by the Niles-Bement-Pond Co., 111 Broadway, New York City. Among their more noteworthy features of design there are included an arrangement for passing the arm through the center of a double column, a motor-driven column-clamping mechanism controlled by a switch on the drill head, an improved type of transmission from the motor to the spindle, and other features which will be dealt with in the following description. It will be seen that provision is made for the application of direct-connected electric motor

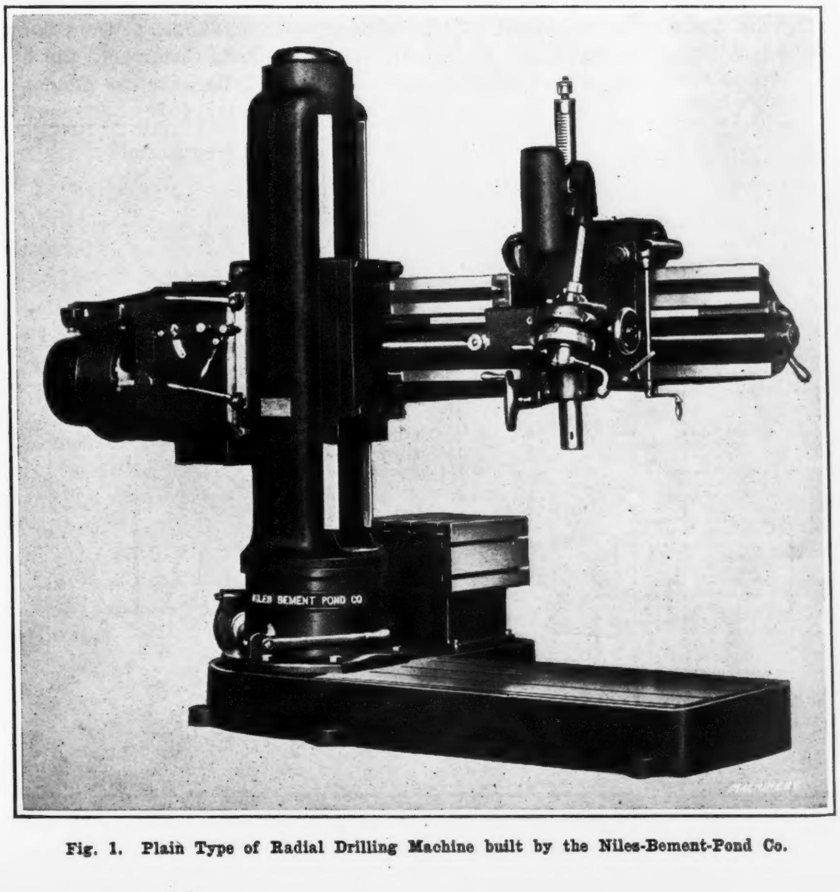


Fig. 1. Plain Type of Radial Drilling Machine built by the Niles-Bement-Pond Co.

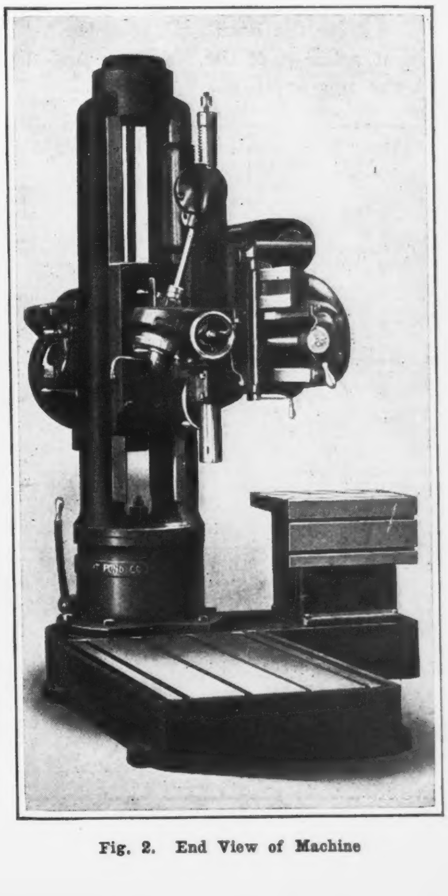


Fig. 2. End View of Machine

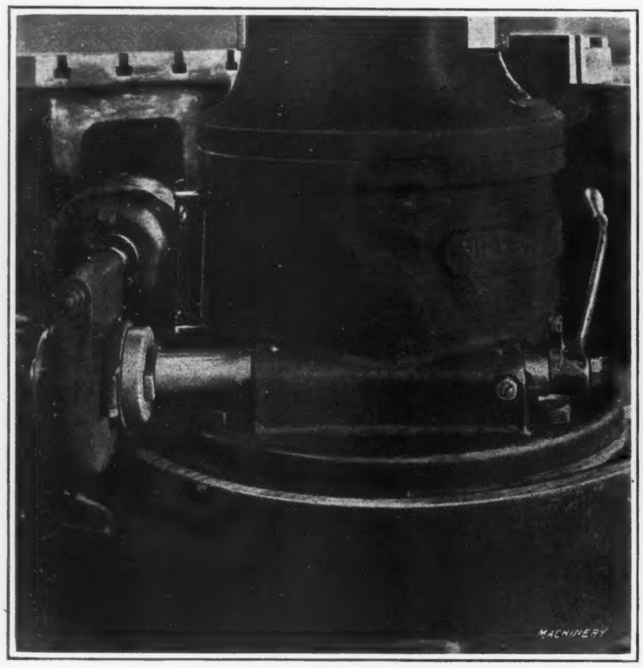


Fig. 3. Column-clamping Mechanism operated either electrically from the Head or by a Hand-lever shown in this Illustration

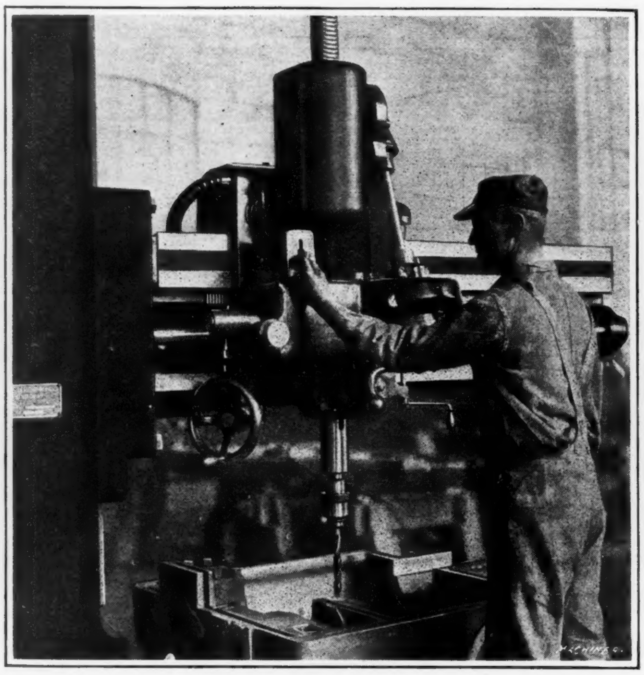


Fig. 4. Close-up View of Drilling Head, illustrating Method of operating a Switch controlling the Column-clamping Mechanism

drive, and other features to which attention is called are the provision of an automatic safety stop for the arm-elevating mechanism, which prevents accidents resulting from overtravel, and interlocking arm-elevating and clamping mechanisms, which prevents damage resulting from simultaneously engaging both of these movements.

The radial arm is of a special cross-section, as shown in Fig. 6, which affords ample resistance to torsional strains, and power is applied to the spindle as close as possible to the drill, the arrangement of this transmission mechanism being illustrated in Fig. 8. Conforming with modern practice in machine tool design, centralized control has been applied on these radial drilling machines, every lever and handwheel being within arm's reach of the operating position. Provision is made for the performance of tapping operations through the application of a reversing motor, which is controlled from the head and provides for reversing the direction of rotation of the spindle when it is required to back out the tap.

Arrangement of the Double Column

Probably the most decided departure from standard practice in constructing a radial drilling machine lies in the design of the column, and Fig. 2 shows this feature quite clearly. This arrangement makes it possible to employ an unusually simple drive from the motor to the spindle. The column is a single casting formed of two box-section members which are cast integral at the top and bottom, with the arm saddle mounted between them. The motor is carried at the rear of the arm saddle, and drives the spindle through a single horizontal shaft running between the column members, the arrangement being shown diagrammatically in Fig. 8. By having the column rotate with the arm it has been found possible to advantageously distribute the metal in the form of a beam section that is said to possess great rigidity for its weight. To provide additional support to the column the trunnion or cylindrical part extends through to the bottom of the base as shown in Fig. 5. V-tracks are employed

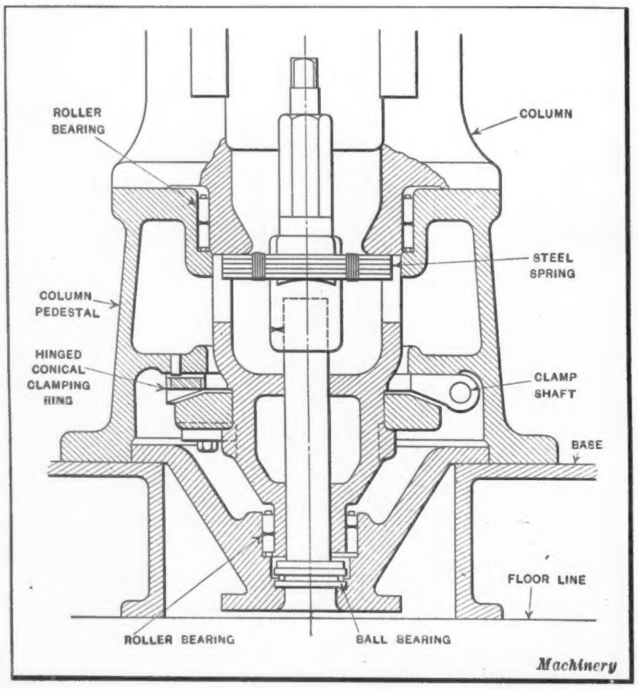


Fig. 5. Cross-section of Column Trunnion, showing how Column extends through Pedestal to Bottom of Base to afford Additional Support

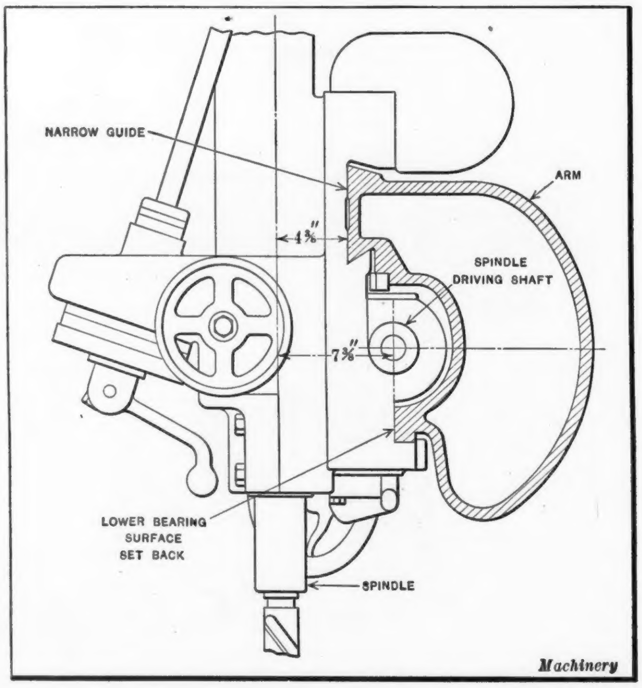


Fig. 6. Cross-section of Radial Arm, showing Lower Bearing set back of Upper Guide to bring Spindle Driving Shaft close to Spindle

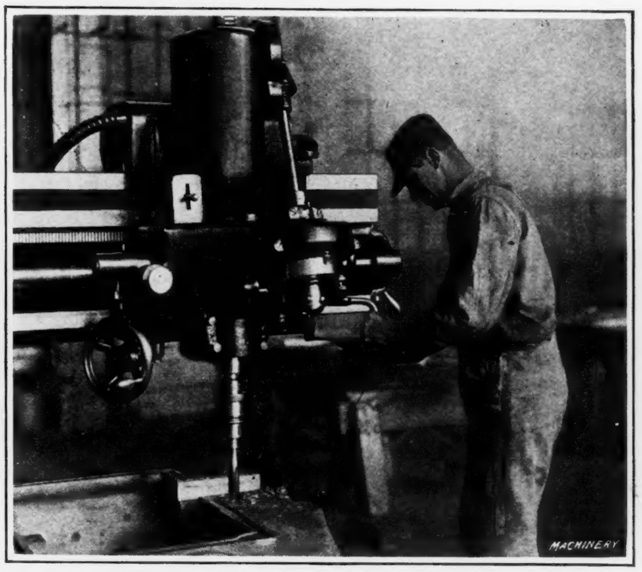


Fig. 7. Close-up View of Drilling Head, showing Method of performing Tapping Operation by reversing Direction of Rotation of the Motor

at the front and rear of the column for guiding the arm saddle, and when clamped by means of a wedge action on these tracks, the arm and column form a single unit.

Electrically Operated Column Clamp

Fig. 3 illustrates an electrically operated column clamp that is provided on these radial drilling machines, and in Fig. 4 the operator is shown manipulating an electric switch on the head which provides for the tightening or releasing of the clamp. This mechanism is instantaneous in action and positively secures the column. In addition to the motor-operated device, a hand-lever is provided for manipulating the clamp, as shown in Fig. 3. Fig. 5 illustrates the clamping mechanism in some detail, from which it will be seen that the mechanism consists of a hinged conical ring acting on the column trunnion. When this ring is contracted by either the power-driven or hand-operated device, it pulls the column flange firmly down on the base. This column flange is of large diameter with a wide bearing on the base, so that when it is clamped there is a broad metal-to-metal contact. When the column is clamped, the roller bearings are entirely relieved of all drilling strains. The electric clamp is operated by a small individual motor which transmits power through a worm-wheel and nut, this mechanism being self-adjusting so that wear can be taken up automatically.

Method of Supporting the Arm and Column

By supporting the entire weight of the arm and column on a ball bearing at the bottom of the column and providing for taking side thrusts on two roller bearings, assurance is obtained that the arm will swing easily. This result is further assured by having the moving parts well balanced, the ball bearing being located almost directly under the center of gravity of the structure. When the clamping mechanism is relieved, the steel springs shown in Fig. 5 lift the column a few thousandths of an inch, so that its flange clears the base. In this way friction at the joint is eliminated and the column and arm turn freely on the ball and roller bearings that are furnished for their support.

As shown in Fig. 6, the arm is of an improved cross-section, which is said to give exceptional rigidity to withstand stresses that are set up while performing heavy drilling operations. There is a narrow upper guide for the saddle, and the lower bearing is set in a plane back of the front surface. This construction brings the driving shaft close to the spindle, and gives plenty of depth from the front to the back of the arm, so that for a given amount of metal an unusual degree of rigidity is said to be obtained. Provision is made for raising and lowering the arm by power taken from the driving motor, which is transmitted through a stationary elevating screw and a revolving nut in the arm saddle. The mechanism is engaged by throwing a clutch lever on the driving-gear box, and it is started and stopped by the controller handle on the drill head.

As previously stated, the elevating and column-clamping mechanisms are interlocking to safeguard them from damage. At this point, attention is again called to the provision of an automatic stop which prevents accidents or damage to the machine, in case the operator should carelessly run the arm to the limit of its travel at either the top or bottom. This device also stops the movement of the arm in case either the arm or spindle strikes an obstruction while lowering it. The elevating screw is hung on a friction ring at the top of the column, and when the arm reaches the top or bottom of its travel, this revolving nut comes into contact with a pin on the screw, causing the screw to turn and thus bringing the arm to a stop. When the spindle or arm encounters an obstruction in lowering, the elevating screw is lifted and turns freely, thus stopping the arm.

Arrangement of the Spindle Drive

Reference to Fig. 1 will show that the driving motor is mounted at the back of the arm saddle, and Fig. 8 illustrates the way in which power is transmitted from this driving motor to the drilling spindle. This unusually simple drive is made possible by the double-column construction. Power is transmitted to the spindle by a horizontal shaft running through the column, and the drive is applied at the lower end of the spindle as close as possible to the drill. This arrangement is the means of conserving the power of the motor. It will be seen that the gears for direct drive consist of two spur gears at the motor end, and two bevel gears and an intermediate double-faced pinion in the drill head. The back-gears are located in a gear-case next to the motor, and they run in oil.

Motor Control on the Head

A motor controller is located on the drilling head, and the spindle may be started, stopped, reversed, or have its speed varied by manipulating a convenient lever. A spindle counterweight is geared directly to the spindle, and it is supported at the center of gravity to eliminate frictional resistance and binding on the guides.

Range of Feeds

There are eight positive geared feeds covering a range of from 0.006 to 0.060 inch per revolution of the spindle. These changes are effected by means of a disk that is graduated to show the rate of feed that is obtained for each position. The feed change-gears are entirely enclosed and run in oil, and they are so constructed that the gears can be removed from the head as a single unit. A sufficient range of feeds

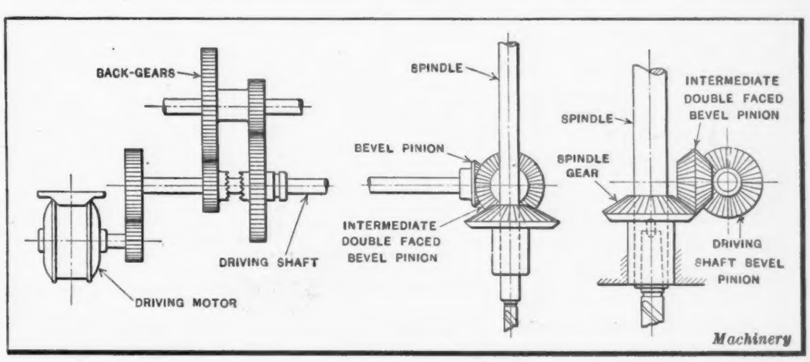


Fig. 8. Improved Type of Direct Drive from Motor to Drilling Spindle through Single Horizontal Shaft and Four Gears, in Addition to which there is One Double-faced Bevel Pinion

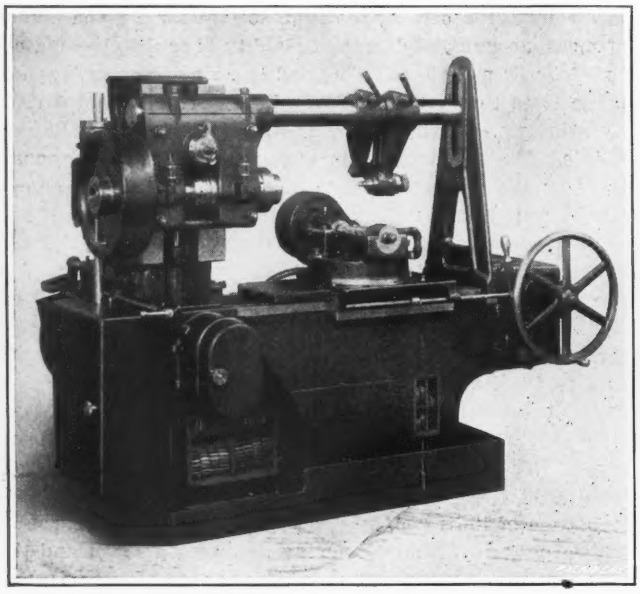


Fig. 1. Sixteen-inch Gear-hobber built by the Cincinnati Gear Cutting Machine Co.

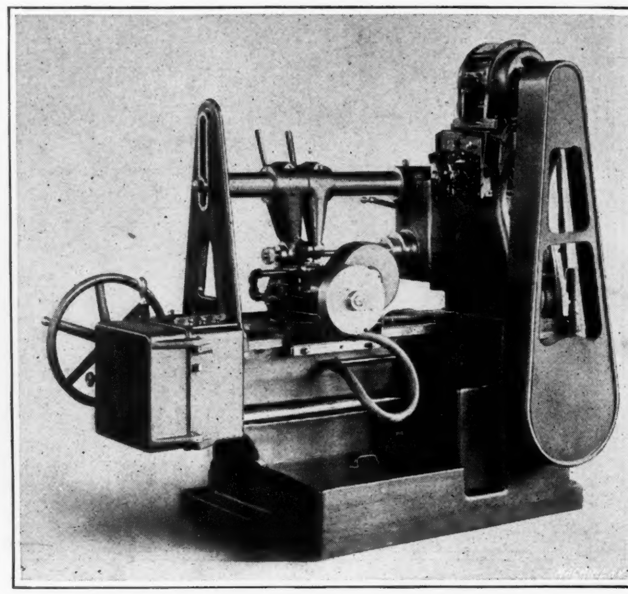


Fig. 2. Opposite Side of the Cincinnati Gear-hobbing Machine shown in Fig. 1

and speeds is available to provide for the performance of any ordinary boring operation that has to be performed on a radial drilling machine; and in addition, the range is ample for all drilling and tapping operations.

Provision is made for quickly and accurately reversing the spindle by reversing the driving motor through the controller that is located within easy reach of the operator. Fig. 7 shows the way in which this result is accomplished. A bottoming tap can be accurately driven to a specified depth, as the motor can be slowed down before the tap bottoms, thus enabling the exact depth to be reached without difficulty.

Depth Gage with Automatic Feed Trip

A depth gage with an automatic feed trip is provided for drilling holes to a given depth, and there are two graduated disks on the head, one of which is adjustable and the other fixed to the feed-shaft. The adjustable disk is set to a pointer at the desired depth of hole, and it is then clamped to the fixed disk by means of a knob, which also acts as a stop to trip the feed-clutch automatically. This disk also carries a safety stop for automatically throwing out the feed at the end of the spindle traverse. The fixed disk is graduated to show the position of the spindle in its traverse. Rapid hand traverse of the spindle is accomplished by means of a knob lever, and a convenient operating feature is that this lever may be pulled down to engage the power feed. Fine hand feed is also provided for the spindle.

Traversing the Head

The drill head is traversed along the arm by means of a handwheel conveniently located at the front of the head, where it is within easy reach of the operator. On universal machines, this handwheel can be swung back out of the way when the spindle is to be swiveled. From Fig. 1, it will be seen that the base has T-slots provided in its finished face. This base is of box-section, and ribbed both transversely and longitudinally. It has an extension at the back of the column and at right angles to the main part of the base, and the table is usually mounted on this extension. There is a reservoir cast in the base and a trough around its edge to collect the coolant. The table is of box design and has T-slots machined in the top and front surfaces. Power for driving the machine is furnished by a 10-horsepower, 4 to 1, variable-speed motor.

CINCINNATI 16-INCH GEAR HOBBER

The Cincinnati Gear Cutting Machine Co., Elam St. and Garrard Ave., Cincinnati, Ohio, has recently placed a new gear-hobbing machine on the market. It is designed especially for the purpose of producing accurate gears at high cutting speeds, and the parts have been very liberally proportioned for the capacity rating of the machine. A front view is shown in Fig. 1, while Fig. 2 shows a rear view. It will be noticed that a large handwheel is located on the operating side of the machine in a position which permits the operator to obtain an uninterrupted view of the work while manipulating the handwheel. The bore inside the work-spindle is ordinarily 2 9/32 inches in diameter, although this can be increased to 2 9/16 inches, which is often an advantage when employing the machine for splining shafts.

INDEX BASE FOR MILLING MACHINE

The index base shown in Fig. 1 is made by the Industrial Engineering Co., 25 Fort St. E., Detroit, Mich. It is designed to reduce the idle time incident to loading and unloading fixtures which are used for ordinary milling machine work. The index base consists essentially of a round table having suitable slots for attaching special milling fixtures, and provision for indexing the table. This arrangement permits the use of a fixture having two work-holding sides, so that the cutters can be operating on the work held on one side while the finished pieces can be removed from the other side and replaced by new work. When the cut has been completed, it is only necessary to index the table 180 degrees and repeat the operation. The large bearings of this base insure rigidity and eliminate vibration, thus permitting heavy cuts to be taken. The base is carefully machined to insure accuracy, and a special clamping device of great power is employed to lock the table. A single movement of the hand-lever with-

Fig. 1. Milling Machine Index Base built by the Industrial Engineering Co.

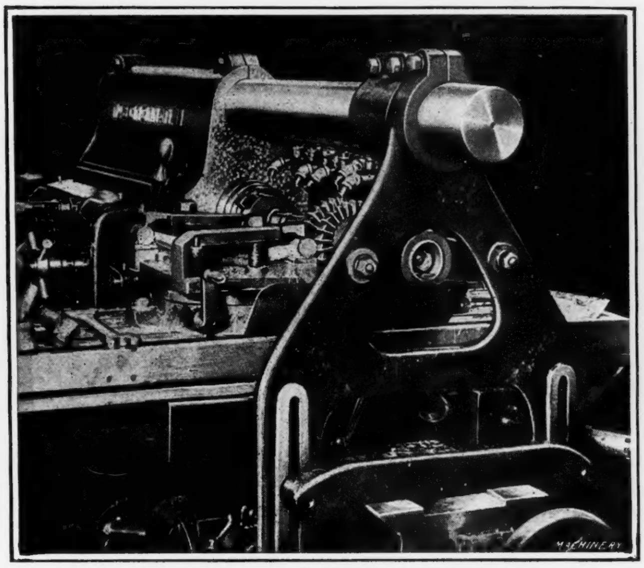


Fig. 2. Use of Industrial Engineering Co.'s Index Base shown in Fig. 1

Adjustable Taper Caliper made by the Knauel Tool Works

out the application of a hammer or mallet is sufficient to clamp the rotating table to its base firmly. When used on a drilling machine, this attachment will be found a great time-saver, as two drill jigs can be mounted on the table, thus permitting one to be loaded while the other is employed for the drilling operation.

In Fig. 2 the index base is shown mounted on a milling machine for milling two steering arms for an automobile. With this arrangement one arm is milled while the operator is replacing the finished piece with a new forging.

LOVEJOY TURRET TOOLPOST

The Lovejoy Tool Co., Inc., Springfield, Vt., has recently brought out a turret toolpost shown in the accompanying illustration. The original Lovejoy positively locked cutter principle is used on all tool-holders which are held in this turret toolpost, and the turning and facing cutters are adjustable for height as they become worn, which permits their cutting edges to be kept in line with the lathe center without sacrificing strength and rigidity.

By one movement of the binding lever, the operator can release and accurately index the turret to the next tool position, where it will be securely clamped in place by the completion of the single movement. The turret rings are approximately 4⅜ inches square, made of hardened steel, and are interchangeable on any base. This interchangeable feature permits the use of additional rings carrying a variety of tool combinations for various jobs, without disturbing the individual cutter adjustment, as well as a quick method of changing tools from outside to inside work.

The boring-bars are 1 inch in diameter and are free from projections, and they will cut to the bottom of a hole which is only slightly larger than the bar itself. However, special boring-bars ¾ inch in diameter with bushings can be supplied if desired. The turning tools have a shank diameter of 1 inch, and are furnished with 19/32-inch high-speed steel cutters. The round shank permits of rotating the holder to produce any desired side clearance, and also provides for a small amount of end adjustment without disturbing the height of the cutting edge, which is a convenience when used on lathes equipped with diameter stops or feed-screws having direct-reading dials. This toolpost will interchange with any regular engine lathe toolpost without requiring any special fitting of the lathe.

Turret Toolpost made by the Lovejoy Tool Co., Inc., for Use on Engine Lathes

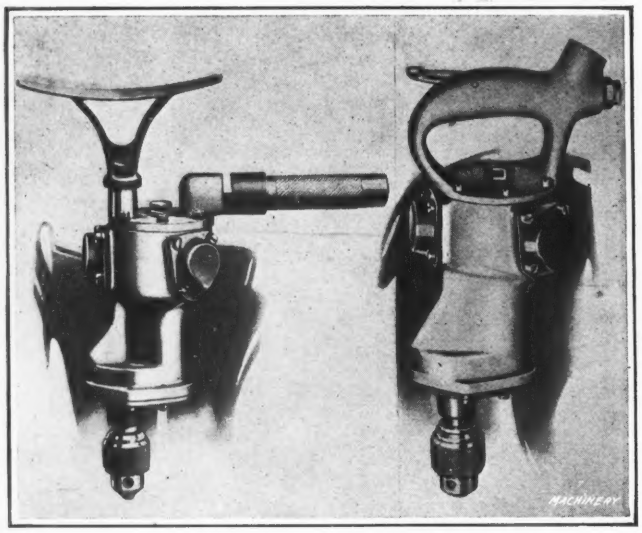
KNAUEL ADJUSTABLE TAPER CALIPER

The taper caliper shown in the accompanying illustration is made by the Knauel Tool Works, Rock Island, Ill. It consists essentially of a V-shaped member, and a straight-edge that can be instantly adjusted and locked in position opposite the V-shaped member as shown in the illustration. This taper caliper provides a substantial and convenient tool for use in the duplication of tapered work. It is made in different sizes to accommodate Brown & Sharpe taper shanks of all sizes from Nos. 1 to 10.

INGERSOLL-RAND PNEUMATIC DRILLS

The Ingersoll-Rand Co., 11 Broadway, New York City, has recently brought out several new sizes of small portable pneumatic tools. These new tools include a small sized pneumatic drill for close-quarter work, known as No. 8, and a small high-speed pneumatic grinder made in two types—Nos. 601 and 602—also a light-weight drill furnished in two styles known as Nos. 6 and 600. These tools have been developed to satisfy the demand for light-weight high-speed tools that are adapted for operating on certain classes of work for which the heavier types of tools are not so well suited.

The No. 600 and No. 6 drills, shown at the left and right, respectively, in the accompanying illustration, are especially designed for drilling small holes with a minimum amount of drill breakage. They will handle twist drills from the smallest size up to ⅜ inch in diameter. The free speed at 90 pounds air pressure is about 2000 revolutions per minute.



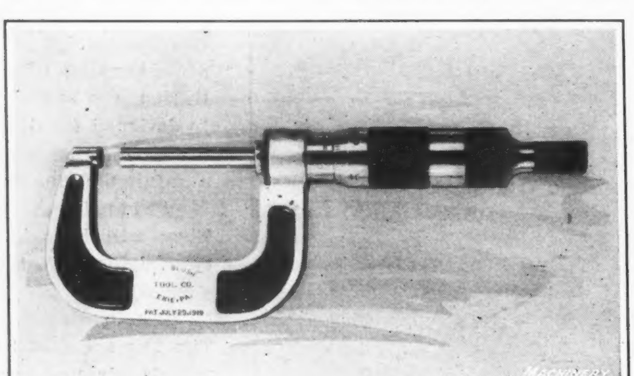
No. 600 and No. 6 Pneumatic Drills made by the Ingersoll-Rand Co.

The two tools differ essentially in the handle construction, the motor being the same in both types. The No. 6 drill has the pistol grip type of handle, while the No. 600 is furnished with breast-plate and rolling throttle handle. Aluminum reinforced with steel bushings, is used where practicable, and this results in a very light machine, the No. 6 weighing only 9 pounds. The motor is of a three-cylinder type and similar to those used in the Nos. 601 and 602 pneumatic grinders. The cylinders are separate iron castings, easily accessible, renewable, and interchangeable. All rotating members have either ball or roller bearings.

The No. 8 close-quarter drill, referred to previously, is especially designed for drilling close to a wall or corner. This machine runs at 250 revolutions per minute without load, and will handle drilling, reaming, or tapping work up to 1¼ inches. The Nos. 601 and 602 grinders are light-weight, high-speed tools running with a free speed of 4200 revolutions per minute and are suitable for grinding, buffing, or polishing work of a varied nature. These two machines are similar in design, the principal difference being the method of control; the No. 601 has the closed type of inside trigger handle while the No. 602 is fitted with the rolling type of throttle handle.

BLUSH MULTIPLE MICROMETER

A new type of micrometer, the purpose of which is to eliminate the necessity of using two instruments when taking measurements ranging from 0 up to 2 inches, has been recently developed by the A. T. Blush Tool Co., 1145 W. 11th St., Erie, Pa. This is accomplished by the use of two screws or threads having different pitches, namely, a 20-pitch thread on the measuring screw and a 40-pitch thread for the thimble carrier. Although the mechanism embodies two screws, the arrangement is such that the accuracy depends entirely upon the 20-pitch thread, as the function of the 40-pitch thread is simply that of keeping the thimble in proper alignment with the graduations on the hub. The difference in the pitch and travel of these threads makes it possible to obtain a 2-inch movement of the spindle with only a 1-inch movement of the thimble.

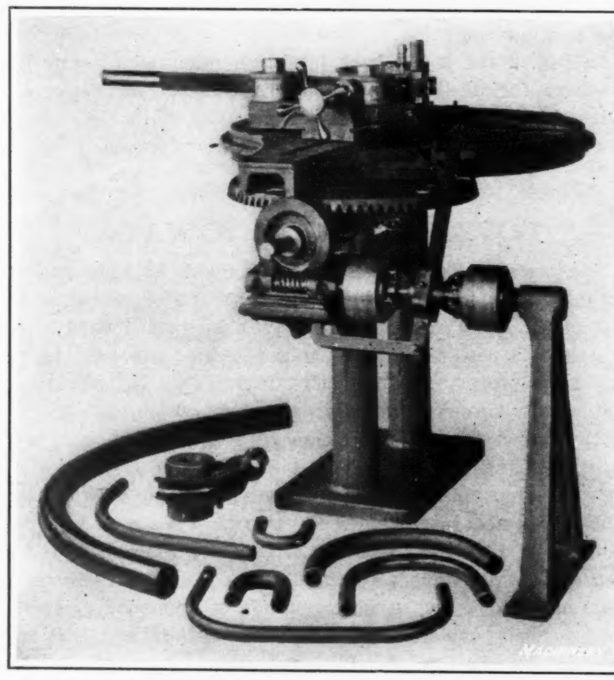


Multiple Micrometer made by the A. T. Blush Tool Co.

The adjustment for wear on the anvil and spindle is made without changing the position of either the anvil or the measuring nut, which is a very desirable feature, as there is absolutely no chance for the anvil and the spindle to be turned out of parallel when making adjustments. Arrangements are being made to manufacture this micrometer in several combinations such as, 1½ to 3, 2 to 4, 3 to 5, 4 to 6, and 5 to 7 inches.

WALLACE PIPE AND ANGLE BENDERS

The pipe bender shown in the accompanying illustration is made by the Wallace Supplies Mfg. Co., 412-420 Orleans St., Chicago, Ill. This machine is designed for bending pipe while cold and, to some extent, without the use of an inside follower or floating mandrel. For special forms, however, inside follower bars or floating mandrels are employed. In the lower left-hand corner of the illustration is shown a forming head used when bending pipe or tubing. The standard equipment furnished with the machine consists of four forming heads similar to the one here shown, which may be employed for bending different sizes of pipe as follows: 1-inch pipe to an angle of 90 degrees with a 6-inch radius; 1¼-inch iron pipe to an angle of 90 degrees or less with a 9-inch radius; 1½-inch iron pipe to an angle of 90 degrees or less with a 12-inch radius; and 2-inch iron pipe to an angle of 90 degrees or less with a 14-inch radius. When making a bend, the pipe is secured to the form by means of a strap. Both the outside follower and the form are grooved, and the clearance between the pipe and the follower and form is such that satisfactory results are obtained. The outside follower bar operates between the tube and the roller so that the tube is well supported. This method of supporting the tube prevents the forming of depressions in the pipe.



No. 5-A Pipe Bending Machine built by the Wallace Supplies Mfg. Co.

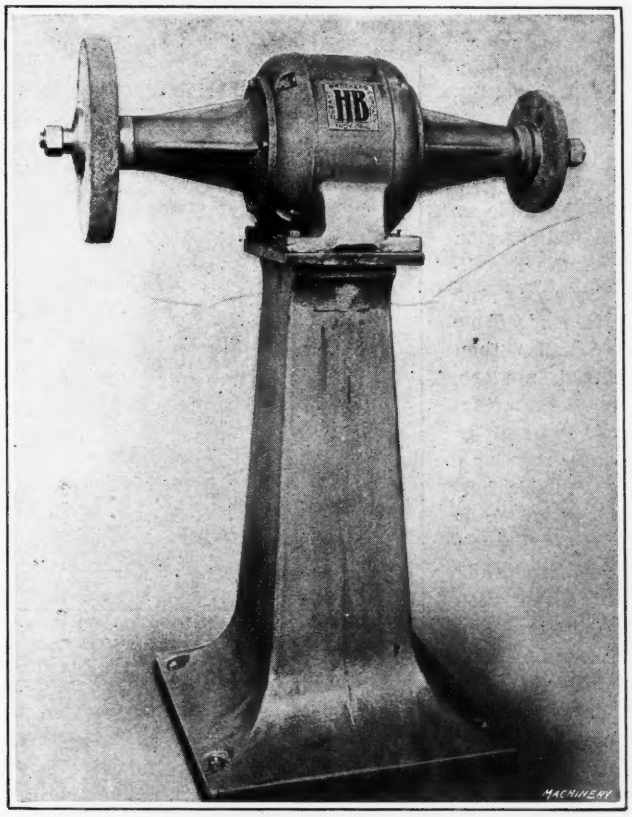
The roller bracket is adjustable and will take forms up to 50 inches in diameter. The machine is controlled by a lever operating two friction clutches which permits the table to be rotated in either direction at the will of the operator. Adjustable stops are provided which can be set to automatic-

ally throw the clutch out of engagement so that the bending operation can be stopped at any desired point. For bending light-gage tubing to a sharp radius, without flattening or crimping, special forms with inside follower bars or floating mandrels can be supplied, which will permit tubing with 1/32-inch walls and from 1 to 2 inches in diameter to be bent to small radii. The approximate weight of this machine is 1200 pounds.

A machine of this type is also made with suitable equipment for bending angles, channels, tees, rounds, squares, twisted squares, or special steel sections, and flat bars on edge.

HOBART MOTOR-DRIVEN GRINDER

A machine known as the H. B. ball bearing motor-driven grinder is a recent product of the Hobart Bros. Co., Troy, Ohio. It is equipped with a two-horsepower ball bearing electric motor, and is adapted for use in grinding castings, sharpening tools, buffing rubber tires, and for the performance of many other operations that have to be handled in garage or machine shops. A buffing wheel or a wire brush wheel can be substituted for one of the grinding wheels.

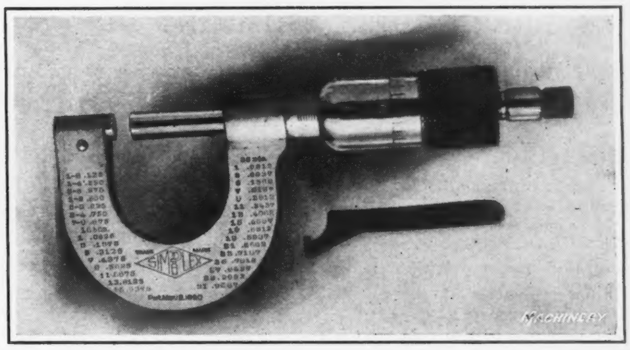


Ball Bearing Motor-driven Grinder built by the Hobart Bros. Co.

This machine is designed for severe service, and it is stated that very little power is consumed in its operation. The bearings may be packed with lubricant so that they only require attention every three or four months. The weight of this grinder is 275 pounds. Either an alternating- or direct-current motor may be furnished on the machine, that is suitable for connection to a regular lighting or power circuit. This grinder occupies a floor space of 20 by 36 inches.

CONSOLIDATED TOOL WORKS DIRECT-READING MICROMETER

The Consolidated Tool Works, Inc., 261 Broadway, New York City, have recently brought out a new line of direct-reading micrometers. The design of these tools is essenitally the same as that of standard types, but they have the

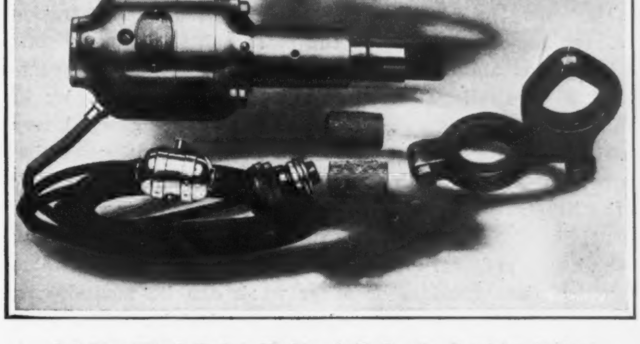


"Simplex" Direct-reading Micrometer made by the Consolidated Tool Works

advantage of direct-reading numerals, which give the exact reading at all times through small apertures in the barrel. This feature not only prevents mistakes being made by unskilled operatives in reading lines, but also avoids errors in computing measurements. There are only two working parts in the direct-reading unit of these micrometers, and both of these units are composed of hardened steel members which are of substantial design. Nine sizes of micrometers are made for the English system of measurement, with a range for taking measurements from 1 inch to 6 inches. The 1-, 2-, and 3-inch sizes can be obtained with graduations reading either to 0.001 or 0.0001 inch, while the 4-, 5-, and 6-inch sizes read to 0.001 inch. These micrometers are also made in six sizes for taking measurements by the metric system. They have a range for measuring to 0.01 millimeter, from 25 up to 150 millimeters. Both the English and the metric system micrometers can be furnished with ratchet stop, lock-nut, or with both ratchet stop and lock-nut.

PRECISION GRINDING WHEEL TRUING MACHINE

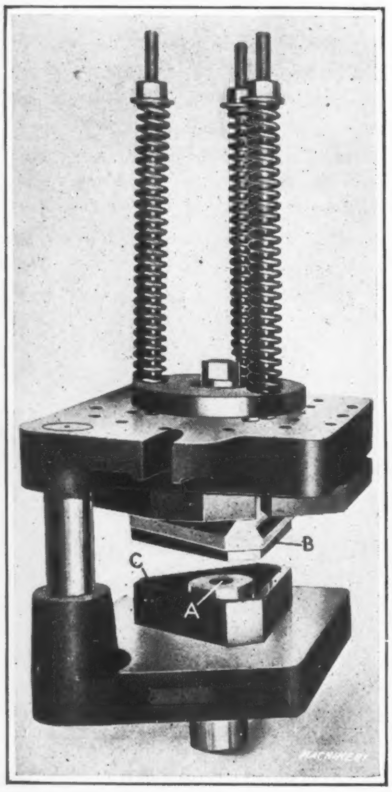
The Precision Truing Machine & Tool Co., Cincinnati, Ohio, has recently developed and placed on the market the grinding wheel truing machine shown in the accompanying illustration. It is claimed that the results obtained by the use of this truing machine are equal, and in some cases superior, to those obtained with a diamond. This machine can be applied to any make and style of grinder, and is operated by either alternating or direct current of 110 or 220 volts. The attaching bracket shown at the right is furnished with each machine, but additional brackets for special or unusual applications can be supplied. Three general-purpose abradant nibs are also furnished with each machine, and nibs for special purposes can be supplied to meet requirements. The general-purpose nibs are 1 inch in diameter by 1½ inches long, and it is claimed that one of these nibs will keep an average grinding wheel in proper condition for 100 hours' continuous operation. The machine has ball bearings throughout, with provision for taking up wear.



Grinding Wheel Truing Machine built by the Precision Truing Machine & Tool Co.

BREHM SHELL TRIMMING DIE

In drawing deep shells under a power press, a ragged or at best an irregular edge is left at the top of the work, which must be trimmed off by a subsequent operation. Such work is frequently done by chucking the shell in a lathe and removing the excess metal with a parting tool, but to facilitate the speed with which this operation can be performed the City Engineering Co., 35 S. St. Clair St., Dayton, Ohio, has developed the Brehm trimming die here illustrated, which has been protected by patents. With such an equipment, it will be evident that the time required to handle work of this kind is far less than that consumed in setting up shells in a lathe to provide for cutting off the excess metal. On the upper die member there is a pilot that enters the opening at the top of the shell, and when the press carries down the upper die member, the shell that is to be trimmed is pushed down into the opening *A* in the lower die.



Brehm Shell Trimming Die made by the City Engineering Co.

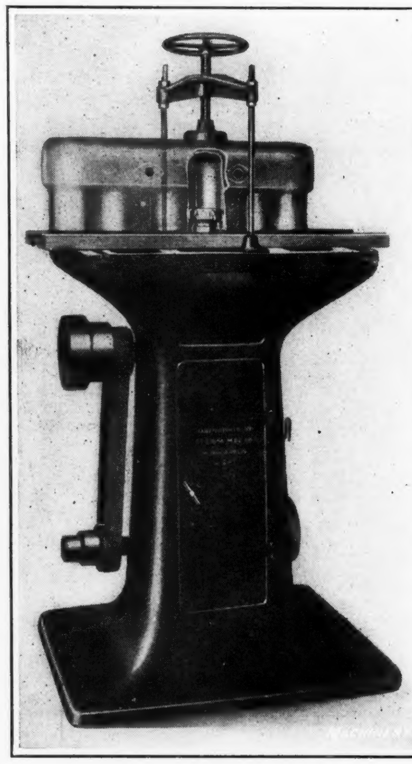
On the upper die there is a floating member *B* on which the previously mentioned pilot is carried, and the die descends until the bottom of the pilot has come almost level with the top surface of die member *A*. When this position has been reached, three cam surfaces on member *B* come successively into engagement with the inner sides of a triangular cam *C* to provide for imparting transverse movements in three directions to the floating member *B*. As the shell has descended into hole *A* to the position at which its upper end is to be trimmed off, it will be evident that these transverse movements of the pilot inside the shell, acting in conjunction with the upper edge of hole *A*, constitute an ideal shearing action to provide for trimming the surplus metal from the top of the shell. The accompanying illustration shows one form in which the Brehm die is made, but there are other designs, and dies will be made in sizes to suit different classes of work.

STORM BORING MILL

The boring mill shown in the accompanying illustration has been recently placed on the market by the Storm Mfg. Co., 6th Ave. and 4th St. S., Minneapolis, Minn. This machine is especially adapted for the boring or reboring of motor cylinders and other parts such as large gears, heavy bushings, tractor wheels, and large holes in castings which are of unusual shape, size, or outside dimensions. Referring to the illustration, it will be seen that the machine consists essentially of the following parts: A main frame or casting of the heavy pedestal type which is provided with a flat table on which the cylinders or other work can be mounted; a boring head which is mounted on a vertical boring-bar supported within the base casting; a device for clamping work to the table, consisting of two upright adjustable bars 40 inches long, a heavy arch, and a handwheel and clamping screw.

The boring-bar is hollow, and it is 48 inches long by 2 9/16 inches in diameter. The heat-treatment to which this bar is subjected gives it great strength and stiffness, and it is claimed that it will withstand a thirty-ton load applied at the center of a twenty-inch length of the bar without springing. Four cutter-heads of the regular Storm multiple-cutter adjustable type are furnished as regular equipment, giving a range for boring holes from 2⅝ to 7⅞ inches in diameter by 20 inches deep. However, special equipment can be furnished for reboring cylinders up to 12 inches in diameter. The cutter-heads are so designed that they can be quickly adjusted by simply turning the adjuster until the desired diameter as measured with a micrometer caliper is obtained.

A centering cone is furnished for each head, so that the work can be quickly centered. When centering a cylinder, it is placed on a table directly above the boring-bar with the head and centering cone in position. The bar is then raised by means of a handwheel, until the cone fits into the bore of the cylinder and raises it slightly from the table or bars. This action draws the bar directly over the cutter-head. The work is then clamped in place, and the boring-bar lowered to remove the cone.

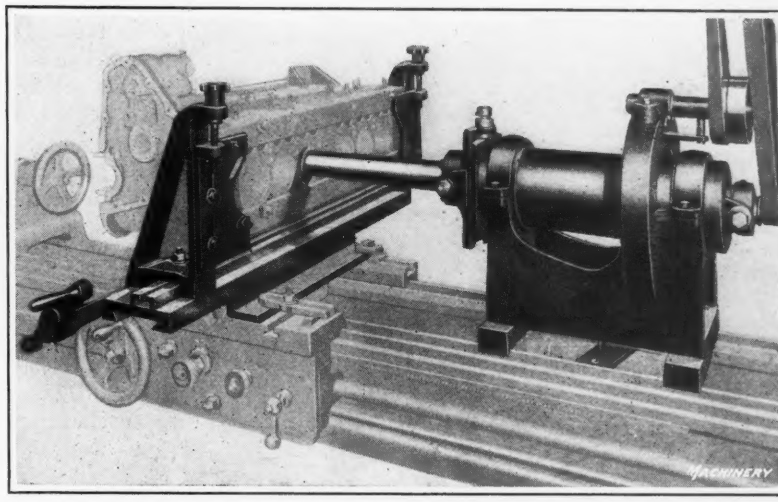


Boring Mill built by the Storm Mfg. Co.

A variable boring-bar speed is obtained through a countershaft and three-step cone pulleys, and positive feed is obtained through cut gears and heavy central steel screws. An automatic return and stop is a feature incorporated in the design of this machine, which is a means of saving considerable time, as the operator can leave the machine after the operation has been started without danger of spoiling the work. This machine, which occupies a floor space of 30 by 36 inches, is 44 inches high, has a table or upper face of 24 by 30 inches, and a shipping weight of approximately 10,000 pounds.

CYLINDER BORING AND GRINDING MACHINE

The cylinder boring and grinding machine shown in the accompanying illustration is made by the Sunderland Machine Shops, 21st and Pacific Sts., Omaha, Neb. This machine is designed for use on any lathe having a swing of from 14 to 24 inches, and it is claimed to be capable of performing either boring or grinding operations with equal facility and accuracy. The machine consists essentially of a cross-slide carrying an adjustable fixture for holding the cylinders, which is designed to be mounted on the lathe carriage, and a head carrying the boring and grinding spindle, as shown in the accompanying illustration. When boring a



Cylinder Boring and Grinding Machine built by the Sunderland Machine Shops

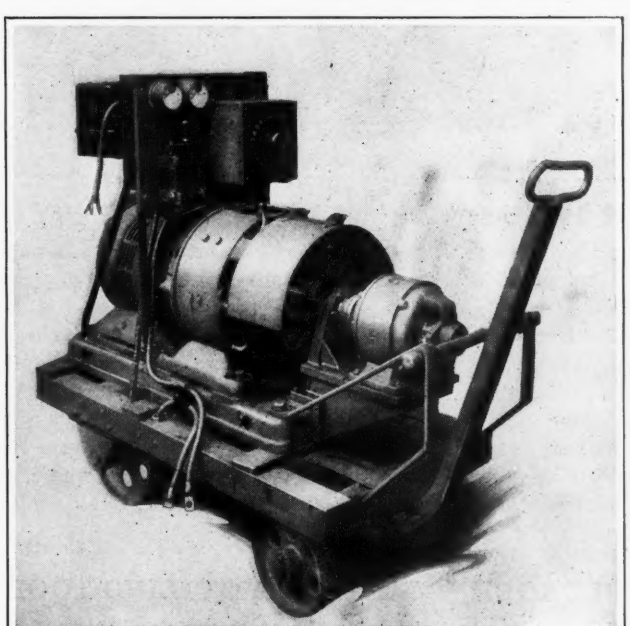
cylinder, the work is mounted in the fixture and so adjusted by the fixture screws and the cross-slide screw that the center of the bore is in line with the center of the boring head.

The boring head is equipped with an outer spindle to which the boring tool can be attached. This spindle revolves at a slow rate of speed and is driven through a large heavy-duty enclosed gear bolted to its outer surface. An overhead belt transmits power to the pinion shaft which is equipped with tight and loose pulleys. The inner or grinding spindle rotates inside the outer boring spindle and is supported by three sets of S K F double-row self-aligning ball bearings which give it the required bearing support, thus assuring a true and free-running shaft that will not throw out, whip, or vibrate. It is claimed that a degree of exactness of 0.00025 inch can be readily obtained with this machine if desired.

Among some of the advantages claimed for it are its low cost, the fact that it can be used for boring or grinding with equally good results, that it can be used on either closed- or open-head cylinder blocks, that it can be mounted or removed from the lathe in ten minutes, that changing the work from one cylinder bore to another requires only a few seconds, and that its use does not interfere with chucking work in the lathe. The capacities are: Swing of spindle, 22 inches; boring and grinding capacities, $2\frac{1}{2}$ inches and larger; and length of spindle, $15\frac{1}{2}$ inches. The equipment includes one main spindle and operating standard, one countershaft, one cross-slide table, two adjustable work-holding brackets, one cutter-head, two grinding wheels, one diamond wheel tracer, one truing-up indicator, and two wrenches. The machine equipment, boxed for shipment, weighs approximately 500 pounds.

WESTINGHOUSE ELECTRIC WELDING OUTFIT

The electric arc welding equipment shown in the accompanying illustration is a recently developed product of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. This equipment is claimed to be exceptionally efficient, due to the fact that the generator operates at the arc voltage and therefore does not require the interposition of a resistance controller between the generator and the arc. The generator is designed to inherently stabilize the arc, thereby eliminating the use of automatic devices such as relays, solenoid control resistors, etc., which not only increase the initial investment and maintenance cost but which are usually not quick enough in action to follow the instantaneous changes in the voltage of the arc circuit.



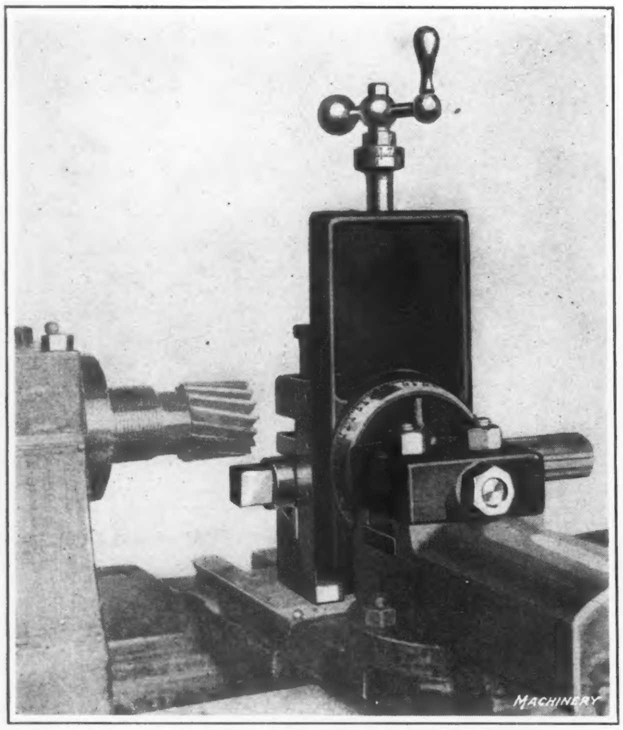
Electric Welding Outfit made by the Westinghouse Electric & Mfg. Co.

The design of the control is such that very close adjustment of current may be easily and quickly made and maintained at the desired point. There are twenty-one voltage rates available ranging from 50 to 225 amperes. This gives a current regulation of less than 9 amperes per step, which is an advantage, especially for overhead work such as that which is encountered in railroad shops or ship construction. Although the generator is strictly a short-arc machine, it is claimed that the arc produced is very tenacious and causes the deposited metal to penetrate deeply into the work. The generator and motor are mounted on the same shaft and bedplate. The motors can be supplied for either direct- or alternating-current circuits. This equipment can be adapted for use on circuits of different voltage by simply changing the connections.

The generator sets are supplied in four sizes having capacities of 300, 500, 750 and 1000 amperes, respectively. The generator is compound-wound, and delivers 60 volts at no-load and also when carrying full load. The commutator is designed so that any momentary overload can be carried without special protection, even at the striking of the arc. The sets of 300-ampere capacity are made in both portable and stationary types, but those of greater capacity are usually employed as stationary sets. Multiple operator equipments are provided with separate control or outlet panels, so that it is possible for several operators to take current from the same generator without interfering with each other's work.

DAVIS LATHE MILLING ATTACHMENT

One of the latest products of the Hinckley Machine Works, Hinckley, Ill., is the Davis lathe milling attachment which is here illustrated and described. This attachment is useful for handling a variety of jobs such as milling plain and Woodruff keyseats, squaring the ends of shafts, splining shafts, splitting bushings, and for the performance of sawing, drilling, boring, and various other operations. The attachment fits any type of lathe with a swing of from 12 to 24 inches. It will be evident from the illustration that this attachment may be swung with a compound rest to bring the work in the right position relative to the cutter. When handling cylindrical work, a steel V-block lines up the piece to be milled, while a filler block is placed above the work so that the two binding screws may securely clamp it in place

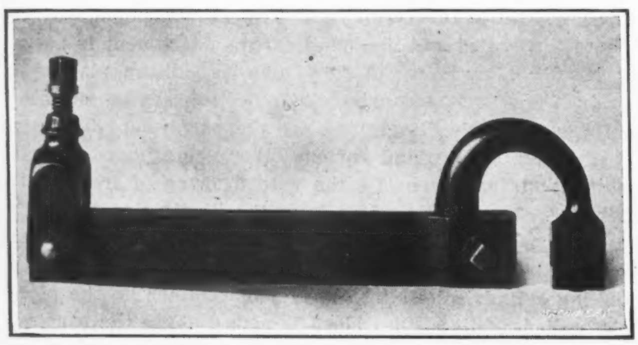


Davis Lathe Milling Attachment built by the Hinckley Machine Works

without marring the surface. The milling cutter is mounted in the lathe spindle. This attachment has a vertical hand feed of 7 inches, while the transverse and longitudinal feeds are provided by the lathe. The vertical feed is accomplished by turning a ballcrank by hand, and the screw has a graduated collar reading to 0.001 inch. Provision is made for swiveling in a vertical plane through an angle of 180 degrees. The vise jaws are 1¾ inches deep by 5⅛ inches wide, and the vise has a maximum opening of 4 inches. The attachment weighs 50 pounds.

DERRINGER COMBINATION TOOL-HOLDER

A combination tool-holder recently perfected by Maurice H. Derringer, 3133 N. Eighth St., Philadelphia, Pa., is shown in the accompanying illustration. This holder is intended for medium sized work, and will hold cutters made from either square or round stock. It is made of steel, and all parts are hardened and drawn. Cutters made from square stock up to 5/16 inch, and which can be used for turning, boring, and internal threading, can be held in one side of the tool-holder. By turning the yoke to the opposite side of the holder, a 45-degree slot is presented which will take round stock from ⅛ to 9/16 inch in diameter. This side of the holder is useful for holding cutters employed in boring or internal threading of small and large holes. This holder is also well adapted for many other kinds of work such as holding an indicator or scriber when setting up work for various machining operations. The yoke, which is attached to the body of the tool-holder, is fastened with a taper pin, and can be removed in a few seconds. This yoke has a 5/16-inch screw and when the holder is placed in the toolpost of a lathe, a double grip is obtained on the tool, the screws in the yoke and the toolpost both gripping the tool so that it is positively prevented from springing.

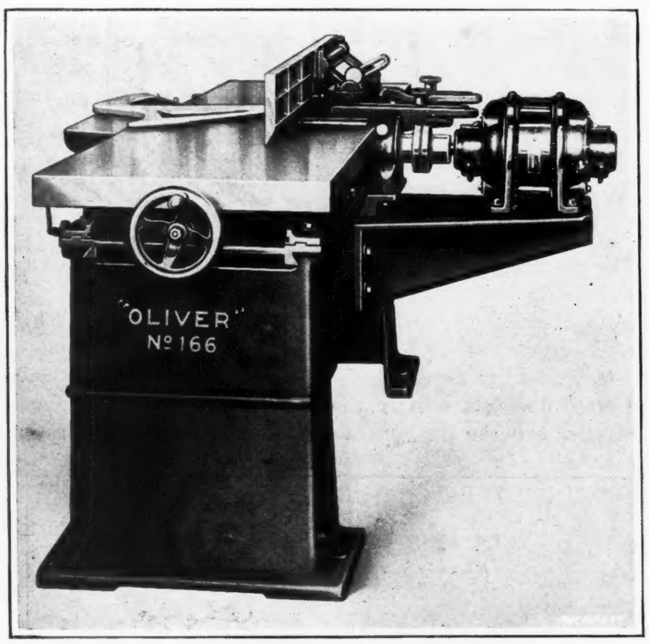


Combination Tool-holder made by Maurice H. Derringer

Another feature of the Derringer combination tool-holder is a spring tool-holder in the form of a gooseneck, which is brought into use by taking out the taper pin that holds the yoke in place and removing the yoke. The gooseneck is then attached with a taper bolt and nut which, when tightened, positively prevents the gooseneck from moving. The spring tool is broached to receive a 5/16-inch tool bit and will be found especially useful for cutting threads. This tool will also be found useful for planer and shaper work as well as for performing turning operations in the lathe.

OLIVER PLANER AND JOINTER

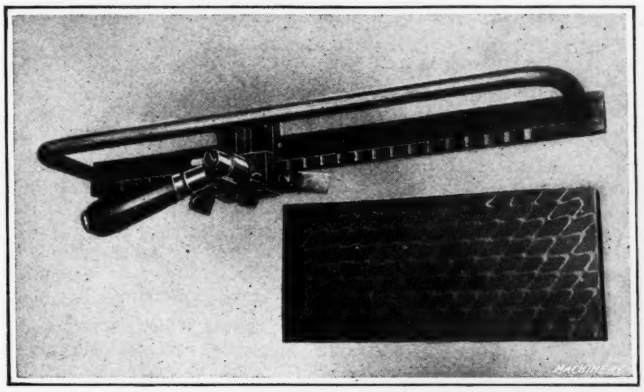
In the August, 1919, number of MACHINERY, reference was made to a No. 166 ball bearing jointer and planer built by the Oliver Machinery Co., Grand Rapids, Mich. This machine had the motor built right into the frame and was limited to the use of three-phase, 60-cycle, 220-volt current. Recently a direct-coupled motor-driven ball bearing planer and jointer of similar design has been added to the line of woodworking machinery built by this company, to permit of the use of any desired motor having a speed of approximately 3600 revolutions per minute. That is, the machine can be furnished for use with either direct current or with alternating current of one, two, or three phase in various voltages. It has all of the advantages of the previous type and eliminates belts and the necessity of using guards; also, there is a saving of floor space. The machine is regularly furnished with three high-speed knives in the head, which is of the round or safety type previously used on this company's machines. This planer and jointer is adapted for use in pattern shops, furniture plants, and other places where a smooth and accurate-cutting jointer is required.



No. 166 Hand Planer and Jointer built by the Oliver Machinery Co.

GULDAGER & JANTSCH MOTTLING TOOL

The mottling tool shown in the accompanying illustration is now being manufactured by the Guldager & Jantsch Co., 460½ Lenox Ave., Detroit, Mich. It is used for fancy scrap-

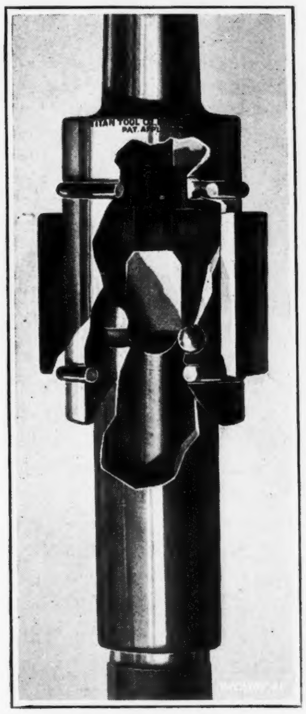


Mottling Tool made by the Guldager & Jantsch Co.

ing or mottling on machine faces, and is intended for work which heretofore has been done largely if not entirely by the hand manipulation of a scraper. The operation of this tool is practically automatic, it being only necessary to move the slide across the work while the operation and guiding of the scraper is accomplished by parts of the machine itself. Different kinds of mottling are obtained by changing the form of the cutting edge of the scraper.

TITAN QUICK-CHANGE CHUCK AND SOCKET

A quick-change chuck having unusually simple features has been brought out by the Titan Tool Co., Erie, Pa. The main feature of this chuck is that the collet is provided with what has been termed a "self-contained drift," so that drills may be removed from the collet without using a taper drift. For this purpose a plunger is fitted at the upper end of the collet, acting against the end of the tang. When the drill is put in place the plunger slips upward; but when the drill is to be removed, a slight blow on the end of the plunger will release the drill. The plunger has a movement great enough to permit it to move out of the way in the drift spline, so that a regular taper drift may be used if desired. A recess is provided in the chuck proper for the end of the plunger.



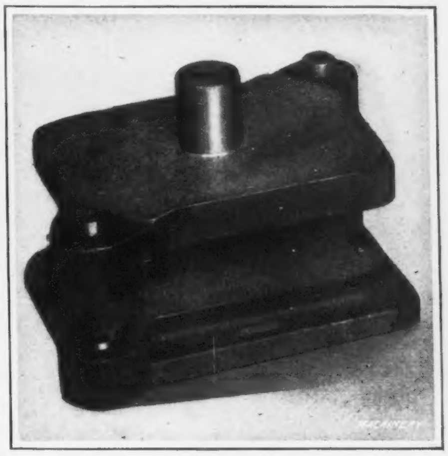
Quick-change Drill Chuck and Socket made by the Titan Tool Co.

The collet is driven from the chuck by means of a pin which bears against a flat milled on the collet. A half circular groove is provided in the collet into which a ball fitted in the side of the chuck enters and thereby retains the collet in the chuck when the chuck ring is down in position to hold the ball in place in the groove. As soon as the chuck ring is moved upward, a counterbore or recess at its lower end permits the ball to move outward, due to centrifugal force, and then the collet can be removed from the chuck very quickly.

This type of chuck will be made to take any size of drill, and can be used in conjunction with the Titan quick-change positive drive chuck for straight drills, so that both straight- and taper-shank drills may be used as required. The chuck body may also be provided with collets for taking broken tang drills, providing for a positive drive on the broken tang.

U. S. TOOL CO.'S SUB-PRESSES

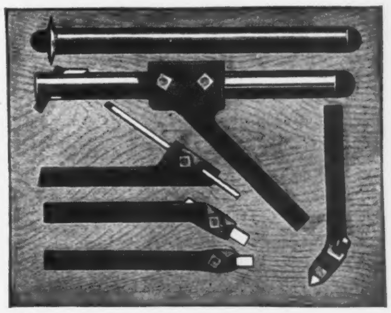
The U. S. Tool Co., Inc., 51-53 Lawrence St., Newark, N. J., is now manufacturing a line of sub-presses of standard design, which are made in various sizes to meet the requirements of different users. These sub-presses are built with two, three, and four pilots; and one of their principal features is said to be the accurate alignment of the pilots. To any experienced mechanic the features of these tools will be apparent from the accompanying illustration, without the need of a more complete description.



Standard Type of Sub-press made by the U. S. Tool Co., Inc.

SET OF "RED-E" LATHE TOOLS

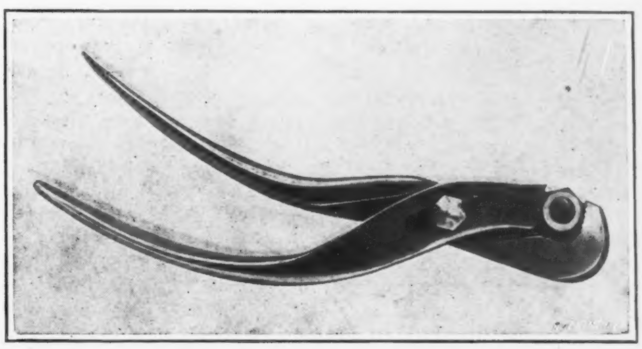
The Ready Tool Co., 650 Railroad Ave., Bridgeport, Conn., has recently brought out a line of lathe tools especially adapted for garages, repair shops, and small machine shops. As shown in the illustration, this set consists of an offset cutting-off tool, an offset threading tool, an inside boring-bar with a holder, an inside threading bar provided with an extra cutter, and a board on which the tools are mounted. All the cutters are made of high-speed steel, except the threading cutters, which are made of tool steel, properly hardened and drawn. The holders are designed to hold tools ½ by 1 inch.



Set of Lathe Tools, made by the Ready Tool Co. for Use in Garages and Jobbing Shops

ALLAN-DIFFENBAUGH PIPE AND NUT WRENCH

The tool shown in the accompanying illustration has been recently put on the market by the Allan-Diffenbaugh Wrench & Tool Co., Baraboo, Wis. It can be instantly adjusted to fit any size of pipe or nut within its capacity, and a powerful grip is obtained with this wrench, as the arrangement of



Pipe and Nut Wrench made by the Allan-Diffenbaugh Wrench & Tool Co.

its two sliding bearings and the fulcrum give a compound leverage. The jaws are always parallel, a feature which makes this wrench especially well adapted for tightening or removing nuts. The length of the tool is 8 inches, the maximum jaw opening 3/4 inch, and it is only 3/8 inch thick and 1 1/8 inches wide when closed.

NEW MACHINERY AND TOOLS NOTES

Motor-driven Hammer: C. C. Bradley & Son, Inc., Syracuse, N. Y. Helve hammers of the regular type manufactured by this company, which are equipped with motors included as part of the hammer equipment.

Drilling and Centering Machine: Cadillac Tool Co., 268 Jefferson Ave., Detroit, Mich. A single-end drilling and centering machine capable of drilling 17/32-inch holes in steel, which can be furnished with either belt or motor drive.

Four-post Screw Press: Manhattan Machine & Tool Works, Grand Rapids, Mich. The Type BB four-post screw press intended for testing punches and dies, etc. This press has a capacity of 80 tons, a bed 20 by 36 inches, maximum distance from bed to ram 22 inches, and a weight of about 2270 pounds.

Diamond Truing Tools: Tungsten Tool Co., Inc., 110-114 W. 42nd St., New York City. A line of diamond-pointed tools intended for use in truing abrasive wheels. The diamonds are mounted in drill-rod nibs by a patented process which does not require the diamonds to be subjected to the injurious effect of heat.

Double-end Tapping Machine: Cadillac Tool Co., 268 Jefferson Ave., Detroit, Mich. A double-end tapping machine designed for simultaneously tapping both ends of turnbuckles or similar work. It is made in five sizes ranging from 12 to 60 inches between the ends of the spindles and for tapping holes up to 5/8 inch.

Electric Starting Switch: Harvey Machine Co., Los Angeles, Cal. A starting switch for use with alternating-current motors of from 1 to 7 1/2 horsepower and 110, 220, 440, and 500 volts. Among other improvements are included push-button control, separate starting and running contacts, improved type of contact point, and simplicity of construction.

Oil-filtering Cabinet: Wayne Oil Tank & Pump Co., Fort Wayne, Ind. Type C oil-filtering cabinet designed to be placed below the machine from which the oil is to be filtered so that surplus oil from the bearings will flow to it by gravity. This type of filter is built in four sizes which are claimed to have capacities for filtering from 100 to 600 gallons of oil per hour.

Slotting Attachment for Milling Machine: Cleveland Milling Machine Co., Cleveland, Ohio. A slotting machine attachment that can be clamped directly to the column and located in place by two pins at the top of the base. It is graduated for close settings and can be rotated through 180 degrees. Any length of stroke can be obtained from 0 to 4 3/4 inches.

Piston Blasting Machine: Gray Machine Tool Co., Inc., Buffalo, N. Y. A machine designed for cleaning the inside of pistons with steel grit or shot, which is said to be capable of cleaning from 140 to 150 pistons per hour. The machine occupies a floor space of 36 by 42 inches, weighs 800 pounds, and consumes about 40 cubic feet of air per minute at 70 to 90 pounds pressure.

Oil-fired Furnace: Tate-Jones & Co., Inc., Pittsburg, Pa. A new design of rotary hearth-type oil-fired furnace having a revolving carriage or hearth, 16 feet 6 inches outside diameter, 6 feet 6 inches inside diameter, and 5 feet wide. The motor-driven hearth makes one revolution in the time required for a single carburizing operation, and is so designed that it can be operated continuously.

Indicator Holder: Guldager & Jantsch Co., 460 1/2 Lenox Ave., Detroit, Mich. An indicator holder made to fit the blades of try-squares which is adjustable for different widths of blades from 2 to 3 inches. Steel balls are used for sliding contacts so that the holder can be easily moved up or down the try-square blade. A conveniently located thumb-screw provides for locking the holder in any desired position.

Rustproofing Process: Andrews Rustproofing Laboratories, 821 Book Bldg., Detroit, Mich. A process of rustproofing ferrous metals by which the minute cavities in the metal are first penetrated by an oxide generated in a furnace in which the pieces are enclosed. Following this treatment the pieces are placed in an oil bath which causes the pores to be filled with a rustproofing paste. The final operation of quenching causes the pores to contract and thus effectively seal up the deposits.

Pneumatic-motor Hoist: Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill. A pneumatic hoist equipped with a two-cylinder double-acting pneumatic motor provided with an automatic stop which shuts off the air before the cable is fully wound and which can also be adjusted to stop the motor for any length of lift within the capacity of the hoist. These hoists are made in six sizes, ranging in capacity from 1/2 ton to 2 tons with a lift range of from 10 to 40 feet at a speed of from 8 to 32 feet per minute.

Aerial Grinder: Van Dorn Electric Tool Co., Cleveland, Ohio. A suspension type grinder weighing from 26 1/2 to 31 pounds, which has a 12-inch extension carrying the abrasive wheel well out from the frame. The device is made either with a direct-current motor, of 1/2 horsepower and 110-220 volts, running at 4000 revolutions per minute; or with an alternating-current polyphase motor of 1/3 horsepower, 110-220 volts, running at 3600 revolutions per minute; or with an alternating-current single-phase motor of 1/2 horsepower, 110-220 volts, running at 3600 revolutions per minute.

Transferring Device for Screw Machine: Brown & Sharpe Mfg. Co., Providence, R. I. An automatic machine developed in this company's screw machine department for use in machining a small brass key bearing. With this machine, the pieces are automatically cut from bar stock and completely machined at the rate of 1080 per hour, including a slotting operation. The special feature of this device is the transfer arm which automatically carries the piece from the first operating position, where it is formed, drilled, and cut off, to the second position, where it is faced off and subsequently dropped down a chute on a traveling belt, which carries it under a slotting saw.

Vacuum Chucks and Pumps: Crescent Sales & Engineering Co., Detroit, Mich. A vacuum chuck and pump manufactured by the Crescent Pump Co. The chuck is intended for holding non-magnetic work and is made of a non-magnetic material. It consists of a vacuum chamber, in the top surface of which there is a series of very fine holes. When in use the work is placed on the perforated surface with a gasket of thin paper between the chuck and work to prevent leakage. The rotary pump developed for use with the vacuum chuck is claimed to be capable of producing a vacuum of 28 1/2 inches. It can also be employed as a blower, in which capacity it will produce a pressure of 15 pounds.

Track Scales: E. & T. Fairbanks & Co., St. Johnsbury, Vt. Light- and heavy-duty scales designed to meet the specifications recently adopted jointly by the American Railroad Association, the Bureau of Standards, and other associations. The scales are built in four sections with a series of primary or main levers transmitting the load to longitudinal extension levers, which, in turn, transmit the load to a transverse extension lever connected through a shelf lever to the beam. It is built in two capacities for light-duty service where only a relatively small number of cars are to be weighed. The capacity of the two light-duty scales is 60 to 75 tons per section, respectively. For heavy service or where a large number of cars are to be weighed, the scale is built in capacities of 75 and 100 tons.

* * *

Some idea of the rapid development of the hydro-electric resources of France within the past few years may be gained from the following statements which appeared in a recent Department of Commerce report. Between 1916 and 1918 it is estimated that 450,000 horsepower was developed, bringing the total development up to the time of the armistice to 1,250,000 horsepower. Projects started in 1919 totaling 175,000 horsepower and construction planned for 1920 and 1921 which will develop 225,000 horsepower will, when completed, bring the total up to 1,650,000 horsepower by the end of 1921.

* * *

United States Civil Service Commission announces an open competitive examination for research engineer on July 20. A vacancy at the Watertown Arsenal, Watertown, Mass., at $3000 to $3600 a year and vacancies in positions requiring similar qualifications at these or higher or lower salaries will be filled from this examination. Applicants should apply for Form 2118, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C., prior to the hour of closing business on July 20.

ROUTING AND ESTIMATING COST OF GEARS AND MACHINE PARTS

The methods used by the Brown & Sharpe Mfg. Co., Providence, R. I., in routing gears and machine parts through the shop, and the manner of estimating the number of labor and machine hours required in the production of a part were described in a paper recently read before the Detroit meeting of the American Gear Manufacturers' Association by J. A. Urquhart. Routing, as the term is used by the concern mentioned, includes ordering the material and tools required in the manufacture of a product, planning the procedure of the various operations and the departments or machines in which they are to be performed, scheduling the date that the work should arrive at each department or machine and the date on which the operation should be completed, and dispatching the work from department to department during the manufacturing process. The purpose of routing is to enable a part to be started at the proper time over the shortest and best route; not to have it in progress for a longer period than is necessary; to have control of the part at all times; and to be able to give positive dates on future deliveries. The practice is to have the part finished or in storage for a short time before it is required.

ESTIMATE NOV. 29, 191

CUSTOMER'S NAME

MR. THOMPSON

PLEASE ESTIMATE ON THE FOLLOWING:	HOURS MACH.	MAN
ROUGHING		
400 DIFF. GEARS	120	120
28 T. 4-5 P.		
MILLING OIL GROOVE	47	47
PER BLUE PRINT C-54118		

TOOLS WANTED: M.H. GARVEY SULLIVAN

4 CUTTERS 3 O.D. 1 1/8 HOLE H.S.

2 SPECIAL MILL. ARBORS

1 INDEX PLATE

NOV. 29, 191 MR. A. MICHAND

NOTICE:

THIS ESTIMATE MUST HAVE YOUR CAREFUL ATTENTION

BROWN & SHARPE MFG. CO.

5668 10M 10-17

Fig. 1. Form sent to Department Foremen for making Estimate on Work to be performed

This routing system was described in an article, "Stock Parts and Their Routing," by Luther D. Burlingame, in MACHINERY for August, 1919. Hence a further description of the routing methods is considered unnecessary; however, the method of estimating the time required to produce a part will be dealt with. In making estimates on gears or machine parts, and especially on new work, it is the practice to obtain the time required for each operation from each department, and the delivery dates. In making this estimate a printed form of the type illustrated in Fig. 1 is sent to each foreman of the departments which have operations to perform. On this form is given the number of pieces to be estimated on. The foreman is also furnished with a drawing of the piece, which gives adequate information to enable him to make an estimate readily. The form and drawing are returned to the estimating department with an estimate of the number of hours required to do the work and a list of the special tools needed. The estimates are then filed for future reference.

When an order is received for a job on which an estimate has been made, a production record card is sent to each of the foremen. A card made out for 1900 gears is shown in Fig. 2. This record card reminds the foremen of what they have promised to do, and has space to permit them to mark the time spent on the job each day so that they can check up and determine whether they are ahead of or behind their estimate. Fig. 3 shows a summary card that is used to record the labor and machine time estimated for each operation. A drawing or photostat of the work is pasted on the back. Cards on which estimates of gears have been made are filed in a cabinet according to the pitch diameter of the gear.

PRODUCTION RECORD

Mr. POTHEN Date 11-13-19

Name Firm

Time No. 7214 | Time Estimated Mch. 150 Man 75

Operation THREADING | No. of Pieces 1900

Remarks

DRIVING GEARS 17 T. 6-8 P.

Hours Estimated should be on this card before starting work. If you cannot do as well or better than Time Estimated notify Foreman of floor. If he cannot produce better results, he will notify the man responsible for this Record.

DATE	HOURS	PIECES	DATE	HOURS	PIECES	DATE	HOURS	PIECES
	MACH.							
NOV. 15	13	257						
" 16	7	143						
" 17	6	128						
" 18	19	381						
" 19	8	128						
" 20	12	256						
" 22	18.5	363						
" 23	6.5	130		MACH.	MAN			
" 24	10	120	GAIN	50 –	25	HRS.		
	100	1906						

Fig. 2. Card given to Foremen for keeping Record of Production of Estimated Work

257-S 1M 9-15

Kind COMPENSATING GEARS

For

Time No.

Work No. T 28 P 7-9

Quantity 10000

Face

Hole

	MACH.	MAN		MACH.	MAN
Drawings		20	8 Ft. G. Cut Machine 5 BRUSH WHEELS		
Patterns CHUCKING	1248	624	O. 5 Machines, and P. 23		
Forging BRUSH		225	28 in. Spiral G. Cut Machine		
Cleaning Castings			Double Tool Gleason Planer		
Machinist's Work		890	12, 24 & 36 in. Gleason Planer		
Screw Machines			Bilgram Planer DRILLING		800
Milling Machines			Auto. Rack Cut Machine		
Milling Machines, P & W.			~~Index Drilling Machine~~ R.V.G.P.	1400	1400
Reed Lathes, Special			72 in. Index Hobbing Machine		
~~Bullard~~ Lathes	3000	1500	Emery Wheel Grinding	1400	1400
Potter & Johnson Lathes			Filing		550
Small Vertical Boring Mill			Hardening $ ——		
Large Vertical Boring Mill			Hobs		
O. S. G. Cut Machines			Tools $ ——		
Hob Machines			Cutters $ ——		
P3, P4, P11 and P13 H.S.	1600	1600	Inspection		624
P5, P6, P14 and Duplex			Boxing		150

Material .10-15 CAR. ST. Date of Estimate Date of Order Remarks

FORGINGS $ ——

Fig. 3. Summary Card showing Labor and Machine Time estimated for Each Operation on a Part

EXHIBITORS IN MACHINE TOOL AND SMALL TOOL FIELD AT AMERICAN RAILROAD ASSOCIATION'S CONVENTION

Air Reduction Co., Inc., New York City.
Ajax Mfg. Co., Cleveland, Ohio.
Ajax Metal Co., Philadelphia, Pa.
American Car & Foundry Co., New York City.
American Tool Works Co., Cincinnati, Ohio.

Baird Pneumatic Tool Co., Kansas City, Mo.
Beaudry & Co., Inc., Boston, Mass.
Besly, Charles H. & Co., Chicago, Ill.
Betts Machine Co., Rochester, N. Y.
Black & Decker Mfg. Co., Towson Heights, Md.
Bullard Machine Tool Co., Bridgeport, Conn.

Cambria Steel Co., Philadelphia, Pa.
Carbo-Hydrogen Co. of America, Pittsburg, Pa.
Carborundum Co., Niagara Falls, N. Y.
Cashman Tool Co., Waynesboro, Pa.
Chicago Pneumatic Tool Co., Chicago, Ill.
Chrobaltic Tool Co., Chicago, Ill.
Cisco Machine Tool Co., Cincinnati, Ohio.
Cleveland Pneumatic Tool Co., Cleveland, Ohio.
Cleveland Punch & Shear Works Co., Cleveland, Ohio.
Cleveland Twist Drill Co., Cleveland, Ohio.
Clipper Belt Lacer Co., Grand Rapids, Mich.
Cutler-Hammer Mfg. Co., Milwaukee, Wis.

Dale-Brewster Machinery Co., Inc., New York City.
Davis Boring Tool Co., St. Louis, Mo.
Davis-Bournonville Co., Jersey City, N.J.
Davis Machine Tool Co., Rochester, N.Y.
Dayton Pneumatic Tool Co., Dayton, Ohio
Detroit Lubricator Co., Detroit, Mich.
Disston, Henry & Sons, Inc., Philadelphia, Pa.
Dixon, Joseph, Crucible Co., Jersey City, N. J.
Duff Mfg. Co., Pittsburg, Pa.
Duntley Pneumatic Tool Co., Chicago, Ill.

Electric Arc Cutting & Welding Co., Newark, N. J.
Elwell-Parker Electric Co., New York City.
Emmert Mfg. Co., Waynesboro, Pa.

Fairbanks Co., New York City.
Fairbanks, Morse & Co., Chicago, Ill.
Foster, Walter H. Co., New York City.
Frontier Chuck & Tool Co., Buffalo, N.Y.

General Electric Co., Schenectady, N. Y.
Gibb Instrument Co., Detroit, Mich.
Goddard & Goddard Co., Detroit, Mich.
Gould & Eberhardt, Newark, N. J.
Grand Rapids Grinding Machine Co., Grand Rapids, Mich.
Greenfield Tap & Die Corporation, Greenfield, Mass.
Grip Nut Co., Chicago, Ill.

Harrington, Edwin, Son & Co., Inc., Philadelphia, Pa.
Hauck Mfg. Co., Brooklyn, N. Y.
Heald Machine Co., Worcester, Mass.
Herbert, Alfred, Ltd., New York City.
Hyatt Roller Bearing Co., New York City.

Independent Pneumatic Tool Co., Chicago, Ill.
Ingersoll-Rand Co., New York City.
International Machine Tool Co., Indianapolis, Ind.

Jacobs Mfg. Co., Hartford, Conn.
Johnson Bronze Co., New Castle, Pa.
Jones & Laughlin Steel Co., Pittsburg, Pa.

K-G Welding & Cutting Co., New York City.
Karry-Lode Industrial Truck Co., Long Island City, N. Y.
Keller Pneumatic Tool Co., Grand Haven, Mich.
King, Julius Optical Co., New York City.

Landis Machine Co., Waynesboro, Pa.
Latrobe Tool Co., Latrobe, Pa.
Luster Machinery Co., Philadelphia, Pa.

Manning, Maxwell & Moore, Inc., New York City.
Metal & Thermit Corporation, New York City.
Midvale Steel & Ordnance Co., Philadelphia, Pa.
Morton Machinery Co., 139 N. Third St., Philadelphia, Pa.

National Lock Washer Co., Newark, N. J.
National Tube Co., Pittsburg, Pa.
Newton Machine Tool Works, Inc., Philadelphia, Pa.
Niles-Bement-Pond Co., New York City.
Nuttall, R. D. Co., Pittsburg, Pa.

Onondaga Steel Co., Inc., Syracuse, N. Y.

Page Steel & Wire Co., New York City.
Production Machine Co., Greenfield, Mass.

Quickwork Co., St. Marys, Ohio.

Racine Tool & Machine Co., Racine, Wis.
Rhodes Mfg. Co., Hartford, Conn.
Rich Tool Co., Chicago, Ill.
Ryerson, Joseph T. & Son, Chicago, Ill.

Sellers, William & Co., Inc., Philadelphia, Pa.
Simonds Mfg. Co., Fitchburg, Mass.
Southwark Foundry & Machnie Co., Philadelphia, Pa.
Swind Machinery Co., Philadelphia, Pa.

Torchweld Equipment Co., Fulton and Carpenter Sts., Chicago, Ill.
Trumbull Waste Mfg. Co., Philadelphia, Pa.

Underwood, H. B. Corporation, Philadelphia, Pa.
United States Graphite Co., Saginaw, Mich.
United States Rubber Co., New York City.

Vanadium-Alloys Steel Co., Pittsburg, Pa.
Victor Tool Co., Inc., Waynesboro, Pa.

Walworth Mfg. Co., Boston, Mass.
Wards, Edgar T. Sons Co., Boston, Mass.
Warner & Swasey Co., Cleveland, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburg, Pa.
Whitman & Barnes Mfg. Co., Akron, Ohio.
Wilmarth & Morman Co., Grand Rapids, Mich.
Wilson Welder & Metals Co., Inc., New York City.

Yale & Towne Mfg. Co., Stamford, Conn.

CONVENTION OF AMERICAN RAILROAD ASSOCIATION

The second annual convention of the American Railroad Association (Section III—Mechanical, including the former American Railway Master Mechanics' and Master Car Builders' Associations) was held at Atlantic City, N. J., from June 9 to 16, inclusive. The opening session was held in the Greek Temple on Young's Pier on June 9, and W. J. Tollerton, general mechanical superintendent of the Chicago Rock Island & Pacific Railroad, who is chairman of the Mechanical Section of the American Railroad Association, called the meeting to order at 9:40. Mr. Tollerton introduced Edward L. Bader, mayor of Atlantic City, who delivered a brief address of welcome.

All of the enclosed space on the pier, including the balconies, was occupied by exhibits of a large variety of different types of railroad equipment. The exhibits of greatest interest to readers of MACHINERY were the machine tools, machinists' small tools, and various auxiliary equipments for use in railroad machine shops. These exhibits occupied the entire south side of the pier and many of the machines were shown in operation so that visiting railroad men were able to obtain a definite idea of the productive capacity and operating characteristics of a number of the latest types of machine tools.

The attendance was comparatively light during the four days of the first week, but this was more than offset in the second week, when a large and representative gathering of delegates was constantly looking over the exhibits on the pier or attending meetings held in the boardwalk hotels. The activities of Section III of the American Railroad Association were partially suspended during the war period; but the activity of this section at the present time appears to be as great as ever and doubtless will result in many improvements in the traffic conditions of our railroads.

OBITUARIES

CHARLES ETHAN BILLINGS

CHARLES ETHAN BILLINGS, founder of the Billings & Spencer Co., Hartford, Conn., died June 5 in his eighty-fifth year. He was born December 5, 1835 in Windsor, Vt. When he was seventeen years old he was apprenticed for three years to the Robbins & Lawrence Co., machinists and gun-makers at Windsor. In 1856 he entered the employ of the Colts Patent Fire Arms Mfg. Co. of Hartford as a toolmaker and die-sinker. In 1862 he was awarded a contract from E. Remington & Sons, Utica, N. Y., to manufacture, by the drop-forging process, certain pistol parts which previous to that time had been made by old-fashioned hand methods. Upon completing the contract in 1865 he returned to Hartford and became superintendent of the Weed Sewing Machine Co. Four years later he became associated with Christopher M. Spencer, the two men subsequently organizing the concern which is now the Billings & Spencer Co. He was president of the company from its organization

until about five years ago, when he retired from active management. For many years Mr. Billings gave personal supervision to the manufacture of the products of the company, and he invented many articles now being manufactured.

WHITFIELD P. PRESSINGER

Whitfield P. Pressinger, vice-president of the Chicago Pneumatic Tool Co., 6 E. 44th St., New York City, died June 10 as a result of complications following an operation. He was born in New York City in 1871. Mr. Pressinger was actively engaged in the pneumatic tool and allied machinery industry for many years. He was general manager of the Clayton Air Compressor Co. for seven years, and became widely known through numerous activities in the American Society of Mechanical Engineers and the Compressed Air Society. In addition to the foregoing societies he was a member of the Engineers' Club, New York Railroad Club, and Machinery Club.

PERSONALS

O. C. Parker, formerly general manager of the Bullock Tractor Co., is now general manager of sales of the Franklin Tractor Co., Greenville, Ohio.

W. A. Dibblee has become field manager for the Western Appraisal Co. and the National Industrial Engineering Co., Atlas Bank Bldg., Cincinnati, Ohio.

Alfred Spangenberg, formerly superintendent of the Reading Valve & Fittings Co., Reading, Pa., has been made works manager to succeed J. T. MacMurray.

R. K. Morse has been appointed western manager of the Milwaukee Electric Crane & Mfg. Co., Milwaukee, Wis., with offices in the Pittock Block, Portland, Ore.

Stanley P. Rockwell, formerly vice-president of the Weekes-Hoffman Co., Syracuse, N. Y., has become metallurgist of the Whitney Mfg. Co., Hartford, Conn.

George H. Earl, who was formerly superintendent of the Otis Elevator Co. at Quincy, Ill., has become associated with the Hollister-Whitney Elevator Co. of Quincy.

George Batzer, who was connected with the Foote-Burt Co., Cleveland, Ohio, for seven years, is now general factory manager with the F. B. Stearns Co. of Cleveland.

Charles T. Caskey, formerly of the Gardner Bryan Co., Cleveland, Ohio, has left this company and is now special factory representative of the Badger Tool Co., Beloit, Wis.

H. A. Baxter, metallurgical engineer of the Tacony Steel Co., Philadelphia, Pa., has been appointed metallurgical engineer of the Penn Seaboard Steel Corporation of Philadelphia, Pa.

John E. Moore, formerly of the Ludlum Steel Co., Watervliet, N. Y., has become associated with the American Machine Products Co., Detroit, Mich., in the capacity of secretary and general manager.

Van H. Manning, director of the Bureau of Mines, Department of the Interior, Washington, D. C., resigned June 1 to take the position of director of research with the recently organized American Petroleum Institute.

George A. Shoemaker has been appointed works manager of the Bound Brook Oil-less Bearing Co., Bound Brook, N. J. Mr. Shoemaker was formerly connected in a similar capacity with David Lupton Sons Co., Philadelphia, Pa.

Robert N. Bird has been made manager of the Perfection Machine Works, Inc., Buffalo, N. Y., manufacturer of gages, fine tools and special machinery. B. J. Phillips, the former president, is no longer connected with the company.

W. H. Patterson, manager of the resale section of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has been appointed assistant to the manager of the industrial department in charge of the metal-working and woodworking industries.

William R. Marshall has been appointed manager of the Industrial Division, New York office, of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., to succeed Harlan A. Pratt, who is now sales manager of the Atlantic Elevator Co. of New York.

Alois Hauser has been appointed assistant to the works manager in charge of engineering, of the Timken Roller Bearing Co., Canton, Ohio. For several years past, Mr. Hauser has been efficiency engineer at the Saucon plant of the Bethlehem Steel Co.

A. G. Norris has been appointed district manager for western New England with headquarters at New Haven, Conn., for the S K F Industries, Inc., 165 Broadway, New York City, sales distributors of the S K F and Hess-Bright ball bearings and Atlas steel balls.

B. G. Prytz has resigned as president of the S K F Industries Inc., New York City, to take the position of managing director of the parent company, with headquarters at Gothenburg, Sweden. F. B. Kirkbride, vice-president of the company, was elected president to succeed Mr. Prytz.

T. W. McManus, master mechanic for the Kellogg Switchboard & Supply Co., Chicago, Ill., for several years past, has acquired an interest in the Security Tool Works, Chicago, Ill. Mr. McManus has been elected vice-president of the company and has assumed the duties of general manager.

Willard S. Sisson, formerly secretary and treasurer of the D. & W. Fuse Co., Providence, R. I., announces that he is no longer connected with that company, as the plant is now operated by the General Electric Co. under a long-term lease. Mr. Sisson will continue in the electrical business.

Clyde E. Dickey, president of the Dickey Steel Co., Inc., New York City, has been elected first vice-president and general manager of the Hammond Steel Co., Inc., Syracuse, N. Y., manufacturer of alloy and carbon tool steels. Mr. Dickey has been engaged in the steel business for the past twenty years.

Edward E. Britigan, for a number of years connected with the American Die & Tool Co., Reading, Pa., manufacturer of automobile transmissions, axles, gears, tools, machinery, etc., in the capacity of engineer, has left this company and expects to devote his time to machinery or automotive sales or service work.

Jacob Auer, formerly superintendent of the De La Vergne Machine Co., New York City, has gone into business for himself under the name of Enterprise Machine & Tool Co., at 903 E. 135th St., New York. Mr. Auer's shop is equipped to do contract work on machine parts, tools, and dies, and general repair work.

Victor J. Smith, for four years connected with the engineering and sales departments of the Cleveland Milling Machine Co., Cleveland, Ohio, is now associated with the Shields Cutter Co., of Cleveland, in the capacity of engineer in charge of general sales correspondence. Mr. Smith will also handle sales in the Cleveland district.

C. E. McArthur, secretary and sales manager of the Modern Tool Co., Erie, Pa., sails from New York July 3 on the *Mauretania* for a two months' visit to England, France, and Belgium, with the purpose of studying the business situation in these countries and the opportunities for the sale of machine tools in the European market.

Robert A. Bole, a director of Manning, Maxwell & Moore, Inc., New York City, and general sales manager of the Pittsburg branch of the business, was elected vice-president of the company at a recent board meeting of the directors. Mr. Bole has been with this company for a great many years, and is well known in the railroad and metal industries.

L. M. Baker, formerly supervisor of sales of the Motor Equipment Division of the Hyatt Roller Bearing Co., New York City, has been appointed exclusive representative in the state of Michigan for the Dittmer Gear & Mfg. Corporation of Lockport, N. Y., manufacturer of automobile, truck, and tractor gears. His headquarters will be in the Book Building, Detroit, Mich.

John M. Price has recently been placed in charge of the Chicago office (1160 Monadnock Block) of the Industrial Controller Co., Milwaukee, Wis. Mr. Price was formerly affiliated with the Mechanical Appliance Co. of Milwaukee, manufacturer of Watson motors, as general sales manager. The Industrial Controller Co. manufactures automatic compensators, starting switches, and a complete line of controlling devices for electric motors.

L. H. KEIM has been appointed general sales manager of the R. D. Nuttall Co., Pittsburg, Pa., gear manufacturer. Mr. Keim has been connected with the company since 1911, having had charge of erection work and the installation of equipment, as well as the designing and developing of heavy-duty railway and steel mill gearing as assistant chief engineer. Mr. Keim will be located in the main office in Pittsburg.

A. H. MITCHEL and E. R. ABBOTT, formerly with H. W. Cotton, Inc., are now associated with the Coe Stapley Mfg. Corporation in charge of the contract sales department, with headquarters at the New York office, 136 Liberty St. The Coe Stapley Mfg. Corporation specializes in the manufacture of sheet-metal parts for automobiles, motorcycles, electrical devices, automobile accessories, phonograph motors and parts, clocks, etc.

C. W. SCHUCHARDT, formerly representing the High Speed Hammer Co., Inc., of Rochester, N. Y., in St. Louis, Mo., has been transferred to Chicago, Ill. A branch has recently been established in Chicago at 568 W. Washington Blvd., where a full line of riveting machine samples is carried in order to demonstrate to customers which size of high-speed hammer will be best adapted to handle their riveting, upsetting, or flush countersinking problems.

W. H. DIEFENDORF, formerly chief engineer of the New Process Gear Corporation, Syracuse, N. Y., and recently general manager of the Weekes-Hoffman Co., of Syracuse, has entered into the gear business at 118 Dickerson St., Syracuse, N. Y., under the name of Diefendorf Gear Corporation. The new company will manufacture spur, bevel, worm, and spiral gears in metal, rawhide, or composition. Special attention will be given to gears for the machinery trade.

FRED THORNLEY, director and works manager of W. Thornley & Sons, Ltd., engineers and iron founders, Sydney, Australia, has come to the United States with a view to purchasing machinery for the company's plant in Sydney, including a fully equipped tool-room. Among the machines required are turret lathes, automatic screw machines, grinding and milling machines, and a complete hardening plant. Mr. Thornley's address is Highland Court Hotel, Hartford, Conn.

CARL WIGTEL, vice-president and chief engineer of the Watson-Stillman Co., 50 Church St., New York City, sailed June 14 on the Swedish-American Line for a ten weeks' trip to the Scandinavian countries. Mr. Wigtel also expects to visit England, France, Belgium and Holland. While he is going mainly for a vacation (this being the first time he has returned to his old home in Norway since his connection with the company thirty-three years ago), he will also investigate new developments in the line of hydraulic machinery in the countries mentioned.

E. M. HERR, president of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., and L. A. OSBORNE, president of the Westinghouse Electric International Co., New York City, were decorated with the Order of the Rising Sun by the Emperor of Japan. Mr. Herr and Mr. Osborne have been in Japan for several months studying Oriental industrial conditions. The Westinghouse companies, which they represent, have had close relations with Japan and have supplied that country with a great deal of power machinery. A number of Japanese students have also been trained at their works.

E. J. BOGGAN, formerly factory manager of the U. S. Metal Goods Co., Cleveland, Ohio, has entered the executive organization of the Dittmer Gear & Mfg. Corporation, Lockport, N. Y., in the capacity of sales engineer. He will devote his entire time to looking after sales matters, including the supervision of sales representatives. Mr. Boggan was formerly associated with the Frontier Chuck & Tool Co. as sales engineer and with the King Sewing Machine Co. of Buffalo as time-study and efficiency engineer. He also served the Covert Gear Co. of Lockport as production manager and the Harrison Radiator Corporation in the same capacity.

COMMANDER R. D. GATEWOOD of the Construction Corps, United States Navy, has been selected as director of construction and repair of the Emergency Fleet Corporation, relieving R. L. Hague. Commander Gatewood graduated from the Naval Academy in 1903 and from the post-graduate course of naval architecture and marine engineering at the Massachusetts Institute of Technology in 1906. He has been in charge of repairs and new construction on both the Atlantic and Pacific coasts, and for two and one-half years was fleet constructor of the North Atlantic Fleet. During the war he was superintendent of motive power for the Panama Railroad, in charge of the large shops and drydocks at both ends of the Isthmus.

ALLAN E. GOODHUE has been elected vice-president in charge of sales of the Chicago Pneumatic Tool Co., 6 E. 44th St., New York City, the position of vice-president having been made vacant by the death of Whitfield P. Pressinger. Mr. Goodhue has been, since May, 1919, managing director of the company's English subsidiary, the Consolidated Pneumatic Tool Co., London, England, as well as director of European sales for the Chicago Pneumatic Tool Co. He was connected for a number of years with the sales department of the Midvale Steel Co. and Midvale Steel & Ordnance Co., leaving that company in March, 1918, to enter the service of the government. From that time until January 1, 1919, when he became connected with the Chicago Pneumatic Tool Co., he was assistant manager of the steel and raw material section, production division, of the Emergency Fleet Corporation.

G. A. UNGAR has been appointed general sales agent and consulting engineer of the "Flexite" division of Slocum, Avram & Slocum Laboratories, Inc., 120 Pacific St, Newark, N. J. Mr. Ungar has been prominently identified with the automotive industry for the last ten years and was the originator of the "Flexite" designs manufactured by this company. He has also been closely connected with the marketing of these products since their inception. In order to devote himself entirely to the commercial development of "Flexite" universal joints and propeller shafts, he resigned his position as technical manager and chief engineer of the S K F Industries. Slocum, Avram & Slocum Laboratories, Inc., has found it necessary, in order to utilize its full facilities for the manufacture of "Flexite" products, to concentrate the manufacturing and selling functions and has inaugurated separate sales headquarters for the "Flexite" products in the Woolworth Bldg., New York City, where Mr. Ungar will be located.

COMING EVENTS

September 14-18—Second annual convention and exhibit of the American Steel Treaters' Society of Chicago, Ill., and the Steel Treating Research Society of Detroit, Mich., in the Commercial Museum, Philadelphia, Pa. Department of Exhibits, 208 N. Wabash Ave., Chicago, Ill.

September 20-October 9—Sixteenth annual convention of the International Association of Machinists, at Rochester, N. Y.

October 4-9—Annual convention and exhibit of the American Foundrymen's Association at Columbus, Ohio.

SOCIETIES, SCHOOLS AND COLLEGES

Purdue University, Lafayette, Ind. Circular illustrating and describing the engineering experiment station of the university.

Michigan College of Mines, Houghton, Mich. Year book for 1919-1920, containing calendar and announcement of courses for 1920-1921.

University of Vermont, Burlington, Vt. Catalogue for 1919-1920 with calendar and announcements for 1920-1921, courses of instruction, and other relative matter.

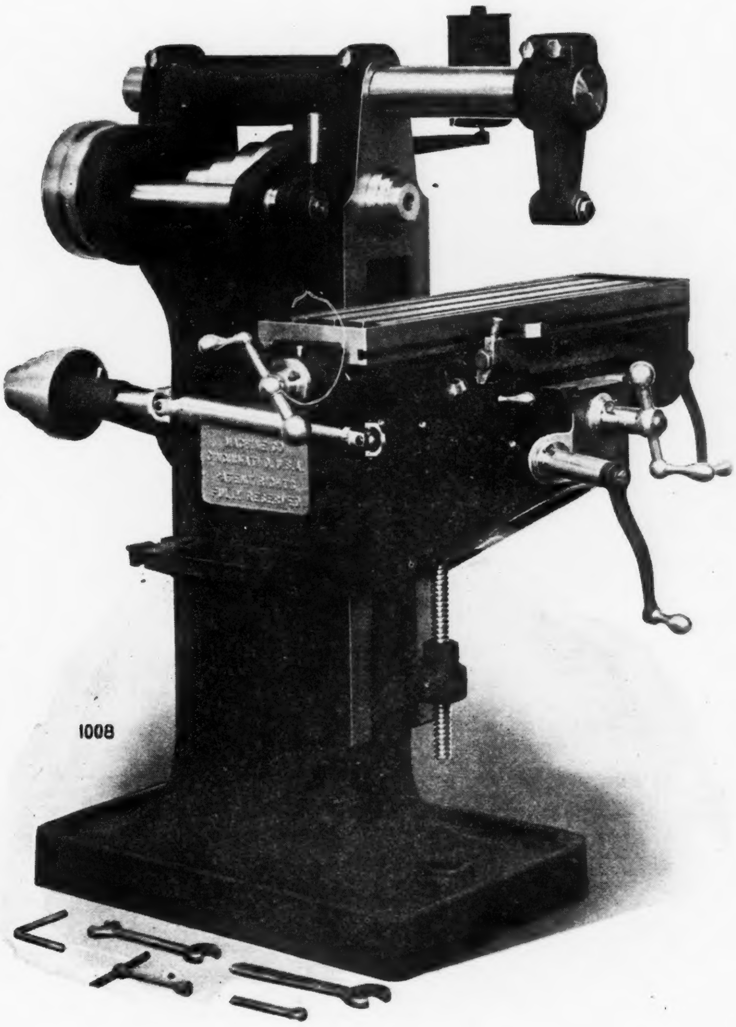
BOOKS AND PAMPHLETS

Electro-deposition of Metals. By George Langbein. Translated with additions by William F. Brannt. 875 pages, 6¼ by 9¼ inches; 185 illustrations. Published by Henry Carey Baird & Co., Inc., 2 W. 45th St., New York City. Price, $7.50.

This is the eighth edition of the present work, which has been revised, enlarged, and entirely reset. The book illustrates and describes processes and apparatus used in plating and finishing metals. It is written in simple language with special reference to the needs of the practical plater and metal finisher, and gives hundreds of tested formulas for solutions, many of which have heretofore been considered trade secrets. It discusses electro-plating, galvanizing, metal coloring, lacquering, and electrotyping, and covers the history and theory of electro-metallurgy. The translator has added considerable matter to the original work, particularly in the chapter on "Apparatus and Instruments" and in the section of "Useful Tables." The present volume describes new developments in machinery and apparatus for this work, such as the latest types of plating machines, ball bearing grinding and polishing lathes, sand-blast apparatus for cleaning, and lacquer spraying by compressed air. It also treats of the use of electrically heated japanning and lacquer baking ovens.

The Engineering Index (1919 Edition). 528 pages, 6½ by 9½ inches. Published by the American Society of Mechanical Engineers, 29 W. 39th St., New York City. Price, $4.

This book comprises a comprehensive guide to the engineering literature of 1919, and should be of considerable value to mechanical engineers and others interested in articles relating to this field. It contains over 12,000 references to nearly 700 engineering and allied technical publications. This volume is the first to be compiled by the staff of the society, the publication having been acquired at the close of 1918. The articles are classified according to subject, arranged in alphabetical order; this arrangement is new, the material in previous editions being grouped under divisions of engineering such as civil, electrical, mining, mechanical, etc. The method of indexing is exceedingly simple; each item contains the exact title of the article indexed, the author's name (if given), the name of the periodical in which the article appeared, the volume, number, and date of publication, as well as page numbers and number of figures. A brief note summarizing each article is included; this feature together with the numerous cross-references throughout the volume, will enable the user to confine his search to those particular articles which bear directly upon his problem. At the back of the book is given a list of the periodicals indexed, place of publication, and frequency of issue; this list covers publications printed in about ten different languages, containing scientific and engineering material.



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THE CINCINNATI MILLING MACHINE CO.
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The Gasoline Automobile. By P. M. Heldt. 633 pages, 5½ by 8½ inches. Published by the author, at Nyack, N. Y. Price, $6.

This is the fourth edition of the second volume of a comprehensive work on the gasoline automobile, this volume dealing with the transmission, running gear, and control. The author is engineering editor of "Automotive Industries," and the treatment is such as to appeal to the designer, rather than the automobile owner or layman. The book gives formulas for designing the gears and other parts of the transmission. It discusses stresses and bearing loads and gives rules for their calculation. The various types of drives are fully described. Attention is given to critical speeds in shafts, the theory of critical speeds being explained and rules for their calculation given. In the present edition, about thirty pages of tabular and other matter have been added to the appendix, which it is believed will materially enhance the value of the book as a work of reference. In the regular text important changes and additions have been made relating to truck axles, control mechanism, and disk wheels, while minor revisions taking account of recent changes in practice have been made in many chapters. The material presented in the book is divided into nineteen chapters, headed as follows: General Lay-out of Cars; Friction Clutches; Sliding Change Speed Gears; Planetary Change Speed Gears; Friction Disk Drive; Universal Joints; Differential Gears; Unit Power Plants; Transmission Axles; Bevel Gear Drive and Rear Axle; the Worm-gear Drive; the Chain Drive; Bevel-spur Gear, Internal Gear, and Four-wheel Drives; Brakes; Front Axles; Steering Gears; Control; Frames; Springs; and Road Wheels.

Automobile Starting, Lighting, and Ignition Systems. By Victor W. Page. 815 pages, 5 by 7½ inches; 425 illustrations. Published by the Norman W. Henley Publishing Co., 2 W. 45th St., New York City. Price, $3.

This is a revised and enlarged edition of a book on automobile starting, lighting, and ignition system practice, written with special reference to the requirements of the reader desiring easily understood explanatory matter relating to all types of automobile electrical systems. Elementary electrical principles are considered before an attempt is made to discuss the features of the various systems. The basic principles are clearly stated and illustrated with simple diagrams. Over 200 wiring diagrams are presented. All the leading systems of starting, lighting, and ignition have been described and illustrated with the cooperation of the experts employed by the manufacturers. Complete data are given for locating troubles in all systems, and full directions are given for making repairs. Various accessories operated by electric current, such as electrical gear shifts, brake actuation, signaling devices, vulcanizers, etc., are also described. An idea of the material presented in the book will be obtained from the chapter heads, which are as follows: Elementary Electricity; Battery and Coil Ignition Methods; Magneto Ignition Systems; Elementary Electric Starter Principles; Typical Starting and Lighting Systems; Starting System Faults and their Systematic Location; Miscellaneous Electrical Devices; Late Ford and Maxwell Electrical Systems; the Hudson-Delco and Two-unit Delco Systems; the Dodge Brothers' Ignition-Starting-Lighting System; the Stutz-Remy and Mitchell-Remy Systems; Bijur-Roamer Electrical Systems; Design of Electrical Measuring Instruments and Use in Testing; 1917-1918 Wiring Diagrams of Popular Cars; 1919-1920 Wiring Diagrams of Popular Cars, Electrical System Details —1920 Cars.

NEW CATALOGUES AND CIRCULARS

Henry G. Thompson & Son Co., 277 Chapel St., New Haven, Conn. Circular advertising Milford hacksaw blades.

Smalley-General Co., Inc., Bay City, Mich. Circular illustrating different sizes of Smalley-General thread milling machines and flange thread millers.

Mattison Machine Works, Rockford, Ill. Circular illustrating and describing the Mattison heavy-duty shaper, which is made in 16-, 20-, and 24-inch sizes.

Ajax Metal Co., Philadelphia, Pa. Leaflet treating of Ajax bull bearing alloy, which is a general-purpose lining metal. Copies will be sent to those interested, upon request.

William L. Procunier, 18 S. Clinton St., Chicago, Ill. Circular containing price lists for "Double-Gripp" safety tapping chucks, tapping attachments, and tap- and die-holders.

Griscom-Russell Co., 90 West St., New York City. Bulletin 1010 containing tables of dimensions, weights, and other data for the Griscom-Russell low-pressure expansion joint for steam lines.

Morrison Machine Products, Inc., 15 Commercial St., Rochester, N. Y. Circular descriptive of the "Inanout" double-acting collet, which combines the principles of the draw-in lathe collet with those of the expanding arbor.

Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. Circular entitled "A Hoist Below the Hook," illustrating the company's line of electric hoists and their application for transporting materials in a wide range of industries.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. Circular entitled "Recent Notable Achievements," illustrating electrical equipment produced by the company for transportation on land and sea, as well as large power generating units.

Sunderland Machine Shops, Omaha, Neb. Circular illustrating and describing the "Fox" cylinder boring and grinding machine, which is adapted for grinding either closed- or open-head cylinder blocks, and is made to fit any lathe of from 14 to 24 inches swing.

Henry Disston & Sons, Inc., Philadelphia, Pa. General catalogue giving dimensions, prices, and other data relating to Disston saws, files, sharpening machines, band saw setting machines, cutter grinders, swages, machine knives, saw clamps, screwdrivers, and other tools.

Norton Co., Worcester, Mass. Circular treating of commercial diamonds for truing grinding wheels, including classification of stones—kinds, color, quality, shapes, sizes, etc.—which should be of value in selecting the proper diamond to use for truing purposes; methods of setting; and suggestions on the correct use of diamonds.

Deming Indicator Co., Dayton, Ohio. Circular giving specifications and prices for the Deming precision test indicator, an instrument for accurately determining minute errors in fine mechanical work. These indicators are furnished in several different sets, comprising the indicator, holder and pointers, in leather covered cases.

Economy Tool Mfg. Co., Green Bay, Wis. Circular illustrating and describing this company's line of tool steel universal tool-holders designed to hold stellite or high-speed steel cutters, for lathes, planers, and shapers. Prices are given for the ten sizes of regular right-hand, left-hand, and straight styles and special straight styles.

Butterfield & Co., Derby Line, Vt. Catalogue 18, covering the company's line of thread-cutting tools, including taps, dies, reamers and screw plates. Sizes and prices are given for the tools listed. In addition, the catalogue contains an appendix of tables and general information relating to standard thread sizes, tap drill sizes, etc.

J. G. White Engineering Corporation, 43 Exchange Place, New York City. Folder entitled "Industrial Buildings at Matagorda," illustrating and giving information concerning the power plant, warehouse, machine shop, and model homes erected for the housing of workmen at the sulphur plant of the Texas Gulf Sulphur Co., Matagorda, Texas.

Smith & Serrell, Central Ave. at Halsey St., Newark, N. J. Bulletin 201, containing data on the "Pulmore" pulley tread—a chemically treated fiber compressed into sheet form for application to iron, steel, wood, paper, or other pulleys in order to produce a frictional tread equivalent to leather. The pamphlet gives list prices and directions for installing.

Portland Cement Association, 111 W. Washington St., Chicago, Ill. Circular outlining the advantages derived through the use of concrete in the construction of mercantile and industrial buildings. The pamphlet is illustrated with views showing a large number of concrete buildings of different types that have been constructed for various classes of manufacture.

Howard Iron Works, Buffalo, N. Y. Catalogue illustrating and giving specifications for the line of bolt, nut, and special machinery made by this concern, which includes nut burring machines, hot-pressed nut machines, nut tappers, bolt and rivet headers, forging machines, bar heating furnaces, forges, facing and boring machines, pickling and washing machines, and gears and transmission equipment.

Vanadium-Alloys Steel Co., Pittsburg, Pa. Booklet descriptive of "Vasco Vanadium," an alloy steel developed to meet the requirements of great strength, hardness, and toughness. The booklet gives a list of the types of "Vasco Vanadium" and the heat-treatments for the different types, as well as the tools or parts for which each kind is especially suitable. Copies will be sent upon request.

Hyatt Roller Bearing Co., 6th Ave. and 41st St., New York City. Circular entitled "Hyatt Responsibility Follows the Bearing," advertising the engineering service rendered by the company to the buyer of Hyatt roller bearings. Circular entitled "I Wonder what a Drop of Oil Thinks about?" showing a series of humorous pictures analyzing graphically the action of a drop of oil on a Hyatt roller bearing.

Davis-Bournonville Co., Jersey City, N. J. Booklet descriptive of Davis-Bournonville welding and cutting equipment, which is applicable for a wide range of work, from that done in the small repair shop to that of the large metal-working plants. The large systems comprise the production, compression, and distribution of acetylene, oxygen, and hydrogen, with full equipment for operators of welding and cutting torches.

Golden Co., 405 Lexington Ave., New York City. Catalogue 234, describing the universal measuring machines made by the Societe Genevoise d'Instruments de Physique of Geneva, Switzerland, for whom the Golden Co. is the exclusive agent in the United States. These measuring machines employ a single standard scale of permanent precision, and are used for the checking and control of standards and scales of every form.

Famous Mfg. Co., East Chicago, Ind. Pamphlet entitled "Like Finding Money," containing suggestions for saving waste paper and other material, and describing the complete line of "Famous" and "Champion" baling presses for use in baling scrap of all kinds, waste paper, rags, leather findings, shaving and sawdust, sheet metal wire, etc. Copies of the catalogue will be sent to anyone interested in turning their waste material into profit.

Hess Steel Corporation, Baltimore, Md. Booklet entitled "Electric Steel Making," containing a reprint of a paper on "Electric Furnaces as Applied to Steel Making," by Henry Lawrence Hess, delivered before the Baltimore section of the American Society of Mechanical Engineers. Booklet entitled "Steel for Airplane Motors," containing an article reprinted from the "Iron Trade Review," on the production of airplane parts of electric steel by the Hess Steel Corporation.

Fairbanks Co., Broome and Lafayette Sts., New York City. Catalogue 935, containing 256 pages illustrating and describing the complete line of power transmission appliances and elevator and conveying machinery produced by this company. The catalogue contains tables of dimensions, capacities, etc., which should be of value to those who design or install mechanical equipment of this nature. Copies will be sent upon request to executives, engineers, master mechanics, millwrights, and those concerned in procuring the material described.

South Bend Lathe Works, South Bend, Ind. Booklet entitled "First Year Lathe Work," intended as an instruction book for students in technical, vocational, and industrial schools, and for the apprentice in the shop. This book deals specifically with the subject of how to build an 8-inch grinder, giving complete working drawings, with the names of the parts and dimensions, and complete instructions for performing the work. Each detailed part is shown in a drawing by itself, and on the opposite page of the book the instructions for its machining are given.

Sprague Electric Works of General Electric Co., 527 W. 34th St., New York City. Bulletin 44553.1 descriptive of Sprague flexible steel armored hose for railroad service, and giving specifications and list prices for air-brake hose, locomotive tank or tender hose, electro-pneumatic switch hose, etc. Circular B-3567 treating of flexible steel armored hose for industrial work, and showing applications in mines, quarries, machine shops, and industrial plants. The pamphlet includes specifications for air hose, water hose, and steam hose, as well as for the couplings recommended for use with Sprague armored steel hose.

Wellman-Seaver-Morgan Co., Cleveland, Ohio, has issued a series of bulletins Nos. 41 to 48 inclusive, showing some of the company's installations of coal and ore handling machinery; special cranes; hydraulic turbines; hoisting and mining machinery; steel works equipment; coke oven machinery; port and terminal equipment; and rubber machinery. These bulletins show on opposing pages a picture of the particular installation and a working blueprint of each machine. Copies of the bulletins will be sent to anyone interested. The company is also distributing Bulletin 51, treating of the Wellman mechanical gas producer.

Briggs & Turivas, Inc., Westminster Bldg., Chicago, Ill. Booklet entitled "Classified Scrap Iron," containing a classification of scrap iron and steel of various grades, compiled from average practice to enable the manufacturer to segregate his scrap accumulations and quickly identify his scrap in terms of its market value. A table is included giving weights and quantities of rails and accessories in various combinations of tonnage and length of track. Other tabular matter gives the net and gross ton equivalents, equivalent pounds for tons from 1 to 1000, weights of plate, standard gages for sheet and plate iron and steel, and specific gravities and weights.

Moltrup Steel Products Co., Beaver Falls, Pa. Catalogue 1 of Moltrup steel products, which include cold-drawn steel in rounds, squares, hexagons, flats, and special shapes; shafting, screw stock and special polished rod; turned and polished shafting; machine keys, Woodruff keys, and machine rack; and flattened steel plates. The catalogue also contains tables of general data, including weights of round and square steel bars, weights of hexagon steel bars, weights of flat-rolled steel, weights of flat steel bars, circumferences and areas of circles, weights of circular steel plates, weights of sheet and bar aluminum and brass, standard wire gages, and weights of iron and steel sheets and plates in standard gages.

Goddard & Goddard Co., Detroit, Mich. Catalogue B, covering the "Go & Go" line of high-speed steel milling cutters, which includes plain milling cutters, side milling cutters, end-mills, shell end-mills, form cutters, shell drills, reamers, and special tools. The book contains illustrations of the different types of cutters, descriptions of their design, and suggestions concerning the work for which each type is especially adapted, as well

LUCAS "PRECISION"

Boring, Milling and Drilling Machines

Building Large Special Machinery

The photograph shows a Lucas "Precision" Boring, Milling and Drilling Machine set up for milling the lugs on cast-iron rings for a circular loom—one of the many and varied operations brought to this versatile precision machine in the Hartford (Conn.) Special Machinery Co.'s shop. There are two of these machines here. Both five years old and with equally satisfactory service records to their credit—"just the thing" to handle castings of all sizes and shapes such as are used in machine building of this nature.

Let us tell you more about them

LUCAS MACHINE TOOL CO. NOW AND ALWAYS OF **CLEVELAND, OHIO, U.S.A.**

FOREIGN AGENTS: Alfred Herbert, Ltd., Coventry. Societe Anonyme Belge, Alfred Herbert, Brussels. Allied Machinery Co., Turin, Barcelona, Zurich, Benson Bros., Sydney, Melbourne. V. Lowener, Copenhagen, Christiania, Stockholm. R. S. Stokvis & Zonen, Rotterdam. Andrews & George Co., Tokyo.

as complete tables of dimensions and prices. In addition to the catalogue material presented, considerable useful information is given on milling practice, including speeds and feeds for high-speed milling cutters, milling heat-treated steels, tables of weights of round carbon and high-speed steels, dimensions of standard keyways for cutters, dimensions of Brown & Sharpe tapers, and suggestions concerning the proper use of milling machines and milling cutters.

Warner & Swasey Co., Cleveland, Ohio, has published a book in celebration of the fortieth anniversary of the founding of the company in 1880, by Worcester R. Warner and Ambrose Swasey. In 1900 the partnership became a corporation, so that on this occasion is also celebrated the completion of the twentieth year of the corporation. The book contains a brief outline of the lives of the founders, as well as a historical sketch of the founding and development of the company and its products. The results of nearly a half a century of mechanical engineering and scientific progress are portrayed in its pages. An idea of the remarkable strides that have been made in the machine tool field in this time may be obtained by a comparison of the illustrations of the 12-inch hand lathe and the 16-inch monitor lathe, developed in 1880 and 1881, with that of the 3 A universal hollow hexagon turret lathe, produced in the present year. The book is intended for distribution to the members and employes of the company as well as to its many friends, who will undoubtedly read it with a great deal of interest.

Davis-Bournonville Co., Jersey City, N. J. Catalogue of Davis-Bournonville oxy-acetylene apparatus, including acetylene generators, welding and cutting torches, pressure regulators, and portable outfits and supplies. The booklet shows a portable cabinet truck which provides permanent mountings for the pressure regulators inside a steel locker, and safe storage for torches, tools, etc., as well as a new non-flashback welding torch, and new-series press-forged-bronze pressure regulators. Circular containing reprints of articles entitled, "Recent Developments in Oxygen Cutting," by Stuart Plumley and F. J. Napolitan, and "Metallography of Iron and Steel with Reference to Oxygen Cutting," by F. J. Napolitan, read before the American Welding Society. The circular also contains an article on "Heavy Cast Iron Cutting," reprinted from "Autogenous Welding." These articles contain information on what has been accomplished in the cutting of cast iron with the oxy-acetylene torch.

TRADE NOTES

Cinch Fastener Corporation announces that it is now occupying its new factory at 2335 W. Van Buren St., Chicago, Ill.

Gale-Sawyer Co., 36 Oliver St., Boston, Mass., has moved its Detroit office to 289 E. Jefferson Ave. This office remains in charge of E. H. Anthony.

Wagner Electric Mfg. Co., St. Louis, Mo., has opened a sales office and service station at 2007 S. Ervay St., Dallas, Texas, under the charge of Charles O. Rauschkolb.

Dayton-Reliance Tool & Mfg. Co., Dayton, Ohio, manufacturer of the "Quick Change" line of lathe chucks, has been absorbed by the **Quickchange Chuck & Mfg. Co.**, of Dayton, Ohio.

Penn Seaboard Steel Corporation, Philadelphia, Pa., announces that its new blooming mill at New Castle, Del., is now in operation. The mill has a capacity for 20,000 tons of billets, blooms, and slabs per month.

Morrison Machine Products, Inc., 15 Commercial St., Rochester, N. Y., manufacturer of collets for all types of lathes and screw machines, would be glad to receive catalogues from lathe and screw machine manufacturers.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., at the annual meeting of stockholders, re-elected the following directors for three years: Guy E. Tripp, Joseph Marsh, H. H. Westinghouse, Albert H. Wiggin, and George W. Davison.

Detroit Tool Co., St. Antoine St., Detroit, Mich., manufacturer of drilling machines, is erecting a two-story concrete addition to its plant, of 120 by 150 feet. The second floor will be used as a general office and engineering department.

J. Lambercier & Co., Geneva, Switzerland, announce that they are planning to place some of the machines included in their line of machine tools on the market in the United States, and would like to get in touch with American dealers interested in handling this trade.

Lehmann Machine Co., 514 S. Broadway, St. Louis, Mo., is erecting a new plant which will cover an area of 45,000 square feet. This plant is of brick, steel, and concrete construction, with a two-story office building adjoining. The plant will be ready to be moved into in August and will give the company four times its present capacity.

Service Casting Co. has recently been organized at Blanchester, Ohio, and will specialize in making small gray iron castings for the trade. The foundry has been in operation since February 1, 1920, doing contract work. The personnel consists of R. B. Huyett and Charles N. Secrist, both of whom are experienced in foundry and machine practice.

Standard Equipment & Tool Works have recently opened showrooms and offices at 307 St. James St., Montreal, Canada, and are desirous of receiving catalogues from manufacturers of machine tools and kindred lines. They would also like to enter into correspondence with manufacturers of a few good lines who wish to enter the Canadian market. Joseph Presner is manager of the company.

Edward R. Ladew Co., Inc., manufacturer of Ladew leather belting, announces that it is now located in its new offices at 428-430 Broadway, New York City, which will be the headquarters of the general sales department of the company as well as of the New York branch. A new and enlarged stock-room and belt shop, with increased facilities for better service, will also be maintained at this address.

Toledo Milling Machine Co., Toledo, Ohio, expects to move into its new factory building about August 1. The new building, which is of two-story steel and concrete construction is nearing completion, and the machine equipment is being installed daily. The entire building will be given over to the manufacture of the Toledo vertical milling machine, and jigs and fixtures are now completed ready for the production of the first lot of machines.

Millersburg Reamer & Tool Co., Millersburg, Pa., has practically completed its new building, and a full line of modern machine tool equipment is being installed for the manufacture of reamers, taps, and small tools. Production is just starting. The building is of cement and steel construction with metal sash, and will cover an area of 2400 square feet. The officers of the company are M. Edward Wilt, president; William Bower, secretary; and W. A. Shatto, treasurer.

Gillespie Eden Corporation, 50 Church St., New York City, has been organized through the consolidation of the Gillespie Mfg. Co., Gillespie Motor Co., Gillespie Foundry Co., and the Brokaw-Eden Co. The new company will manufacture the Eden washing machine, and castings, motors, and wringers used in its production. The officers are T. H. Gillespie, president; E. L. Bergland, H. G. Seaber, P. J. Holdsworth, and George DeLaval, vice-presidents; H. S. Hart, treasurer; and F. J. Nash, secretary.

Nazel Engineering & Machine Works, Philadelphia, Pa., a corporation chartered under the laws of the state of Pennsylvania, has taken over the business of the estate of the late John Nazel. The officers are as follows: Ralph W. Nazel, president and general manager; C. H. Wackernagel, vice-president and assistant manager; J. Milton Nazel, secretary and treasurer. The change will not affect the business policy of the founder, the managing personnel being practically the same as it has been for the past fifteen years.

Meisselbach-Catucci Mfg. Co., 51 Stanton St., Newark, N. J., manufacturer of automatic gear-hobbing machines, hob and gear-cutter grinders, and automatic machine tools for special work has purchased the shop of the Union Wheel Works which is located at 51 Stanton St. in the Frelinghuysen Ave. factory development. The company is converting the building to meet its requirements, and with the added facilities afforded expects to be in a better position to meet the demand for M-C gears and gear-hobbing machines.

Pennsylvania Pump & Compressor Co., Easton, Pa., announces the opening of sales offices at 50 Church St., New York City, H. C. Browne, manager; 2222 Chestnut St., Philadelphia, Pa., W. J. Devlin, manager; 631 Fulton Bldg., Pittsburg, Pa., C. W. Gellinger, manager; Mutual Bldg., Richmond, Va., W. F. Delaney, manager; 2027 Jefferson Bank Bldg., Birmingham, Ala., H. I. Kahn, manager; Newhouse Bldg., Salt Lake City, Utah, C. H. Jones, manager; and 604 First National Bank Bldg., Milwaukee, Wis., Coates & Zarling, representatives.

Cutler-Hammer Mfg. Co., Milwaukee, Wis., has moved its Chicago offices from the Peoples Gas Building, where they have been located for the past eight years, to the company's own building at 323 N. Michigan Ave., on the new Michigan Blvd. link. Because of the rapidly growing business in the Chicago territory, it was necessary to provide larger office space. The new building also offers considerable extra storage space, and will make it possible to carry a larger stock of standard apparatus and parts for ready delivery. H. L. Dawson is manager of the Chicago office.

Reed-Prentice Co., Worcester, Mass., **Becker Milling Machine Co.**, Hyde Park, Boston, Mass., and **Whitcomb-Blaisdell Machine Tool Co.**, Worcester, Mass., have opened a direct sales office for handling their sales in the New York territory, on the fifth floor of the Grand Central Palace in the International Machinery Exhibition. The office will be in charge of P. K. Dayton, who has been connected with the Niles-Bement-Pond Co., and Manning, Maxwell & Moore. Mr. Dayton will be assisted by P. A. Dyer, formerly of the General Electric Co. These three companies, which are controlled by the same financial interests, have adopted the policy of selling direct to the trade, for the purpose of insuring to their customers prompt and efficient service.

Watson-Stillman Co., 192 Fulton St., New York City, announces the following changes in personnel made at a recent meeting of the board of directors: A. F. Stillman has retired from active interest in the management; E. A. Stillman continues to hold the office of president of the company and also has full supervision of sales; Carl Wigtel, chief engineer, was elected vice-president; J. D. Brocks, was elected treasurer, and A. Parker Nevin, secretary; LeRoy T. Brown was appointed works manager, J. W. Delano, assistant works manager, and W. H. Martin, purchasing agent. Under this arrangement the offices of general manager and superintendent are discontinued, G. D. Kershaw and J. F. Lary, who formerly held these positions, no longer being connected with the company.

Yale & Towne Mfg. Co., Stamford, Conn., announces that it has purchased the Industrial Electric Truck Division of the **C. W. Hunt Co.** of Staten Island. The business will be combined with the Yale & Towne hoist department, and the company will thus be in a position to furnish complete equipment for moving medium or light loads either vertically or horizontally. Arrangements have been completed for increasing the manufacturing facilities at Stamford, and it is the intention to so organize the business as to give maximum service to users of the trucks. The following changes have been made in the organization: John B. Milliken, treasurer of the company, has resigned to enter other fields, and Willard L. Case will fill the position made vacant by Mr. Milliken's resignation. Edward C. Waldvogel, who has been in the employ of the company for fifteen years, and who has held the position of general manager for four years, having charge of all sales and advertising, has been elected a director.

Wayne Machinery Co., Fort Wayne, Ind., has opened a store at 121 S. 3rd St., Louisville, Ky. L. Kenner, who has been connected with the Fort Wayne plant for the last eleven years, is in charge of the new store. In addition to the Fort Wayne plant's line of woodworking and iron-working machinery, the Louisville branch will handle many well-known production lines of wood- and metal-working equipment, among which will be included the machines manufactured by the Rockford Milling Machine Co., Sidney Machine Tool Co., Thompson Grinder Co., Oakley Machine Tool Co., Colburn Machine Tool Co., Rockford Machine Tool Co., B. C. Ames Co., Mueller Machine Tool Co., Queen City Machine Tool Co., Peerless Machine Co., Whipp Machine Tool Co., Adams Co., Hurlbut, Rogers Machinery Co., and Ingersoll-Rand Co. The company also maintains a branch at 18 W. 2nd St., Dayton, Ohio, in charge of H. F. Himes. Representative lines of machine tools are carried at this branch as well as some woodworking machinery.

J. H. Williams & Co., Brooklyn and Buffalo, N. Y., manufacturer of drop-forgings and drop-forged tools, announces the consolidation of the wrench and drop-forging plants and business of the **Whitman & Barnes Mfg. Co.**, Chicago, Ill., Akron, Ohio, and St. Catharines, Canada, manufacturer of twist drills, reamers, wrenches, and drop-forgings, with J. H. Williams & Co. The Whitman & Barnes Mfg. Co. will retain its twist drill and reamer business, and will continue to manufacture these tools on an extended scale as a separate organization at Akron, Ohio. The consolidated business will continue to be operated by those who have been identified heretofore with J. H. Williams & Co., and with the Chicago and St. Catharine's plants of the Whitman & Barnes Mfg. Co., the organization being as follows: President and managing director, J. Harvey Williams; vice-president, A. D. Armitage; secretary and treasurer, W. A. Watson; general sales manager, F. W. Trabold; general works manager, captain W. N. McMunn; general purchasing agent, J. C. Scanlon; and Canadian manager, W. J. Elliott.

Technical Advisory Corporation, 132 Nassau St., New York City, has been organized to act as consulting engineers and industrial economists. The men connected with the new corporation formerly served on the technical advisory committee of the War Claims Board, and will continue to serve the Government in an advisory capacity. The officers are as follows: President, Campbell Scott; vice-president and treasurer, Ernest P. Goodrich; and vice-president and secretary, William D. Ennis. The principal associates are Frank B. Maltby, Walter Rautenstrauch, George B. Frankforter, Arthur W. Hixson, Fred E. Rogers, and Rumsey W. Scott. Two main classes of service will be offered, namely, industrial and engineering. In connection with the industrial section the corporation will undertake work as economists, cost reducers, and business advisers, furnishing studies of and recommendations on problems of production, transportation and distribution. It will prepare authoritative appraisals of real property, equipment, and merchandise, will analyze organization conditions, methods, and personnel, and will undertake problems involved in the harmonization of labor and management. In connection with the engineering section, it will furnish complete factory and institutional lay-outs and specifications based on an approved plan of production and distribution, including all the productive and auxiliary facilities and equipment. Its work covers civil, chemical, electrical, mechanical, and metallurgical engineering in nearly all branches.